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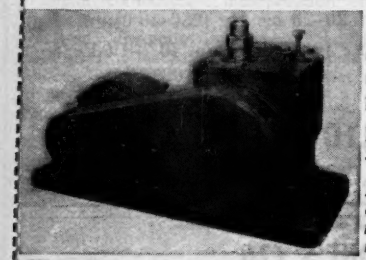

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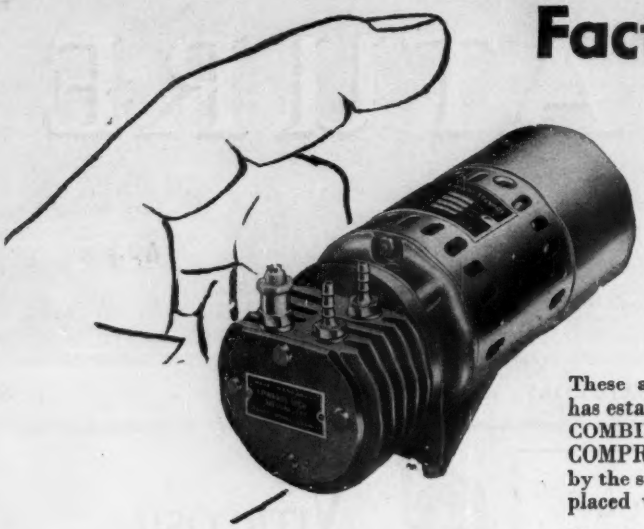

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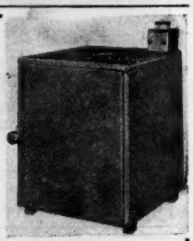

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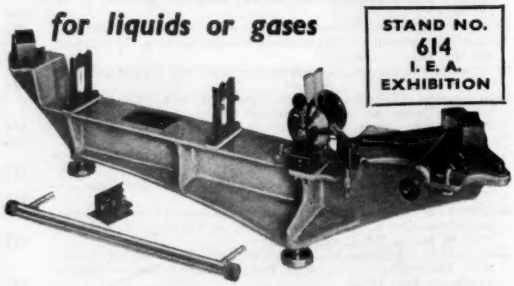

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PRESERVATION OF THE COUNTRYSIDE

A PASSAGE in the report of the Nature Conservancy for the year ended September 30, 1957, discussed the effects on the Conservancy's work of the plans announced towards the end of 1956 for the development of Milford Haven as a major port, capable of taking large oil tankers. The proposals under consideration include an oil refinery on the north side of the Haven and a depot for trans-shipping iron ore from Canada at Angle on the southern side, and there is also a plan to erect a barrage across the River Cleddau. The shores of Milford Haven at its seaward end are in the Pembrokeshire Coast National Park, and nearly three-quarters of the proposed development would be located in the Park. The Haven and the area surrounding it also contain a flora and fauna of considerable scientific interest; and the national nature reserves of Skomer, Skokholm, Grassholm and Flimston Stacks and Cliffs and the sites of special scientific interest at Crabhall Saltings, Dale Point, Sleekstone and Goulthrop Roads, Marloes Sands and Westdale Bay, and Broomhill Burrows may be affected, directly or indirectly, by the proposed developments.

The main threats are the greater disturbance and development arising from an influx of industrial population into previously remote and sparsely inhabited places, the risk of oil and other forms of pollution arising from the increased seagoing traffic and industrial development and the deterioration, or even worse, of scientific interest due to gravel winning, or the deposition of material near Dale Point and Crabhall Saltings. Other problems will inevitably arise from the increase in population and secondary industrial and commercial activities required to support the proposed development which, so far as the Conservancy's interests are concerned, come immediately from those proposed by the Esso Petroleum Co., Ltd., and the British Petroleum Co., Ltd., and by the Milford Docks Co. The companies have given firm assurances that they will do all that is reasonable and within their power to eliminate the risk of oil pollution, or minimize its effects should it occur, and the Nature Conservancy intends to press for the strict enforcement of the Oil in Navigable Waters Act, 1955, which provides the necessary statutory protection, and of the International Convention for the Prevention of Pollution of the Sea by Oil, 1954; and the Conservancy trusts that the oil companies which are authorized to develop sites in Milford Haven will, in concluding charter parties for vessels of countries which are not parties to the Convention, include a clause stipulating no discharge of oil into the sea within 500 miles of Milford Haven. The companies have also agreed to consult the Conservancy before depositing dredged material in any area likely to affect the sites of special scientific interest in the Haven.

An immediate threat has arisen in the proposal to win gravel by dredging in Dale Bay; but following consultation with the Ministry of Transport and Civil Aviation, the Haverfordwest Rural District Council and the development company, agreement has been reached on the issue to the company of a temporary lease for obtaining gravel, subject to certain conditions as to area and amount. It is hoped that fuller information will become available in the course of the development about any possible effect on the sites of special scientific interest, and that by further consultation this can be eliminated or minimized, and surveys have been undertaken to record the present coastal vegetation before any changes take place.

The eighth report of the National Parks Commission, which has since been issued (see p. 950 of this issue), also considers the proposed developments at Milford Haven at some length, though the Commission equally expresses profound misgivings as to the invasion of the Snowdonia National Park by the proposed nuclear power station at Trawsfynydd. It is indeed the scale and nature of such developments that lead the Commission to the uncompromising general conclusion to its report, namely, that such development is wholly alien to the very purpose of national parks, which is the preservation of the distinctive rural character of fine landscape for the enjoyment and recreation of both present and future generations.

The Commission holds that the siting of large-scale industry in national parks should be sanctioned only on over-riding and inescapable national necessity, and after alternative sites outside the national park areas have been zealously sought. In the absence of such proved national need, there is no justification for sacrifice of the essential character of unspoilt country, which is itself a real, if intangible, national need. A countryside once invaded by industry in this way is irretrievably altered in character, and its value for agriculture and for recreation is damaged or for ever destroyed. So important is this value of unspoilt country to a crowded and urbanized island like Britain that we must recognize before it is too late that we are trustees for future generations, and that we can only at our peril disregard that trust.

That general principle is of vital importance in considering the Milford Haven Conservancy Bill*, which was published last December, and also the Commission's approach to the main proposals affecting the Pembrokeshire Coast National Park and other particular developments. In moving the second

* Milford Haven Conservancy Bill. Pp. iv+38. (London: H.M. Stationery Office, 1957.) 1s. 9d. net.

reading of the Bill in the House of Commons on November 22, the Minister of Transport and Civil Aviation, Mr. H. Watkinson, was concerned essentially with the practical purposes of the Bill, which establishes a conservancy authority for Milford Haven to be known as the Milford Haven Conservancy Board. Reference was made to a section of the Bill which would require the Board, in considering any proposals, to have regard to the desirability of preserving natural beauty; conserving flora, fauna and geological or physiographical features of special interest; and of ensuring an easy passage at all times through the waters of the Haven for ascending salmon and sea-trout. But it was left to other speakers, notably Mr. Ness Edwards, Mr. P. Williams and Mr. D. Donnelly, to point out that the way development was handled under the Act would apply the decisive test as to whether the Government has a real concern for the national parks, and to stress the outstanding importance of the amenity issue.

Mr. A. Neave, the Joint Parliamentary Secretary to the Ministry, in replying to the debate, readily responded, pointing out that there are further safeguards in that clauses would restrain the Board from depositing dredged materials so as to prejudice establishment of the Pembrokeshire coastal path; and making the Board subject to the provisions in the Town and Country Planning Act, 1947, would provide a further safeguard for amenities. Similarly, by constituting the Board as a harbour authority under the Oil in Navigable Waters Act, the area would be safeguarded against the danger of oil pollution. Nevertheless, there is need for great vigilance. It would have been more reassuring had the Government sponsors of the Bill directed attention spontaneously to the significance of these features of the Bill. Reference might have been made to the Electricity Act, 1957, Section 37 of which empowers the Electricity Generating Board, any Area Board, the Electricity Council and the Minister to have regard to the desirability of preserving natural beauty, conserving flora, fauna and geological or physiographical features of special interest, and of protecting buildings and other objects of architectural or historical interest, and to take account of the effect of any proposals on these objects. As the Nature Conservancy points out in its annual report, such clauses have removed the danger that legal or financial action required to make desirable and fair arrangements may prove *ultra vires*. The National Parks Commission also expresses satisfaction that this and other new and more satisfactory provisions relating to the holding of public inquiries, while not resolving the problems of the ever-increasing conflict between the claims of industrial development and that less tangible national asset, an unspoilt countryside, have given statutory recognition to the importance of this aspect of planning.

Nevertheless, the National Parks Commission is seriously concerned at the effect of industrialization on the scale contemplated at Milford Haven on the national park area. Some two-thirds of a 900-acre site for the Esso Petroleum Co. jetty and oil refinery would be within the National Park. The Commission submitted at the public inquiry last July that the developers should be obliged to show beyond doubt that there is no other site available outside the National Park which would meet the material requirements.

As regards the proposals of the British Petroleum Co., while the Company has been concerned to minimize their effect on the landscape so far as it is able, the Commission is particularly concerned with the effect of the suggested form of tank. These tanks, 140 ft. in diameter and 60 ft. high, would be seen over a wide area as an incongruous element in the landscape, and although the Commission's recommendation that no tanks should be erected in a defined part of the area was not written into the proposals, the Pembrokeshire County Council, as local planning authority, was given control over the siting. Since the Bill received Royal Assent in July 1957 there have been discussions on the site on the best measures for making the tanks less obtrusive.

A third development at Milford Haven to which the National Parks Commission refers is that proposed by the Steel Company of Wales for building a jetty and establishing a stocking ground for iron ore at Chapel Bay on the south shore well within the Park. The Commission believes that this project would be totally at variance with any conception of the right use of land in a national park, and hopes that the Company will seek an alternative site elsewhere. That hope is unlikely to be fulfilled now that the Minister of Housing and Local Government has approved the oil refinery project. The other developments will almost inevitably follow, once it has been conceded that the incomparable advantages of the Haven for the very large tankers which are likely to carry much of our oil supplies in the near future constitute a national interest over-riding that of amenity even in a national park area; and it is of course such future and secondary developments, with the consequent profound changes in the whole character and appearance of the area, that are at the root of the Commission's objections.

That much conceded, whether rightly or wrongly, the utmost care should be taken to see that the destruction of amenity is kept to a minimum, and that positive action is taken to offset the inevitable loss of some natural beauty. The Milford Haven Conservancy Bill has left the House of Commons, but something could still be written into it to ensure that adequate means, such as a new town corporation, well financed and competent to handle all these developments and consequential changes, are available. It is unfair and unwise to place all the responsibility for planning and financial aspects on the local authority, even when it has proved itself as capable as the Pembrokeshire County Council of taking long views and seeking the national interest. It is already clear that the companies primarily concerned are willing and anxious to play their part, and the current annual reports of both the Nature Conservancy and the National Parks Commission testify as fully to what can be done by co-operation and with goodwill and public support as they do to Government parsimony in its refusal to provide the

resources to make the National Parks Act effective. Indeed, the Dolphin Development and Management Co. has already offered to serve, without fee, as planning consultants to the Pembrokeshire County Council in collaboration with its planning officer and, through him, in liaison with the Ministry of Housing and Local Government.

This offer goes far to meet the most urgent need which follows from the Minister's approval of the project of the Esso Petroleum Co. Only something in the nature of a regional development corporation can prevent the worst effects of industrial development from repeating themselves in the area, and reconcile the conflicting demands on the use of the land which will arise from housing and social needs. Foresight as well as adequate financial resources are required, and the powers and resources of a small and sparsely populated county are hopelessly inadequate to deal with such a situation. Although it may prevent development in the wrong places, it cannot effectively induce development in the right places, even if it can tell where the right places are. Failure to place adequate resources at the disposal of the National Parks Commission has already undermined its work, and often prejudiced local authorities against it. Milford Haven provides a decisive test of the sincerity of the Government's support of the National Parks which no protestations of economy can evade; finance, in fact, is the crux of the situation.

At the public inquiry into the iron ore stocking proposal, the Pembrokeshire County Council and the National Parks Commission claimed that reasonable requirements of the Steel Company of Wales for a deep-water jetty and ore stocking ground in Milford Haven could be adequately met with less injury to the amenities of the National Park at Ferry Cwm, to the east of Bullwell. At this inquiry, however, the first under the new procedure adopted in accordance with recommendations of the Franks report, the Admiralty indicated that while it had no objections to the Chapel Bay site, it reserved the right to consider all the implications if any other site were seriously considered. The Admiralty claims were not disclosed, but the announcement may well weaken public confidence in the new system at the outset.

The position at Milford Haven, however, has implications elsewhere, and it is in the light of what has already been decided there that the proposal to place a nuclear power station at Trawsfynydd in the Snowdonia National Park should be considered. The Commission has already expressed its concern to the Minister of Power, and a public inquiry has opened since its annual report was issued. Lord Strang, in addressing the Council for the Preservation of Rural Wales, said explicitly that although there is a *prima facie* case for saying that the facilities offered by Milford Haven cannot be found in comparable degree elsewhere, it is not clear that any such argument can be advanced for the location of a nuclear energy station in the middle of the Snowdonia National Park. It does not appear, in fact, that any comprehensive survey of alternative sites has been even contemplated by the Central Electricity Authority, and although the Commission has already informed the Minister that this development appears to be incompatible with the maintenance of the area as a national park, it is already apparent that the local authorities, to which, in defiance of the National Parks Act, the Minister of Housing and Local Government has entrusted the administration of the Park, cannot be relied on to set the national before supposed local interest. The Merioneth County Council has from the start welcomed the scheme and set local employment before the national interest of amenity.

Evidence given at the inquiry on February 13 put a new and alarming face on a proposal which now looks even weaker than was supposed. Not merely is the life of the power station to be no more than twenty to forty years, but also, when the reactor reaches the limit of its effective life, it can be neither brought up to date nor demolished except at enormous expense, but must be left to cool down for perhaps half a century. The electricity plant, however, is still there and could be used or modernized, and also the network of power-lines. It would seem that the full implications of the nuclear power programme have not yet been considered.

What is to happen when the reactors are worn out? Will entirely fresh sites be sought, or will a fresh reactor be placed beside the first? It makes all the difference to the treatment of any proposal to enter an area such as a national park, if the encroachment is to be one of steady accretion. Indeed, if the life of a power station is to be only two decades or so, the argument against entering a national park area at all is almost unanswerable, while that for putting the reactor underground in any event is enormously strengthened.

What was disclosed at this inquiry has already made the very moderate and reasonable representations of the National Parks Commission quite inadequate. It is imperative, if preservation of amenity as a national interest has any meaning, that the full report of the inquiry should be published, and that the Ministers concerned, both the Minister of Power and the Minister of Housing and Local Government, should be pressed closely in Parliament to indicate clearly the views and intentions of the Central Electricity Authority in regard to the obsolescence and replacement of power stations, the implications of obsolescence and the policy they propose to adopt in regard to the protection of amenity. The cost of the whole programme for the development of nuclear energy needs to be reconsidered. If that programme is to threaten the national park areas, nature reserves and areas of exceptional natural beauty or scientific interest, it should include adequate financial provision for underground building or for the demolition of a reactor, at whatever cost, within, say, a decade of ceasing to use it. Until this is done, we are evading the real cost of nuclear power development and are betraying our trusteeship for our land and its natural beauty. The scale and pace of development have now taken us far beyond the point at which the nation can postpone paying the price demanded if anything of its natural and scenic heritage is to be preserved for this and future generations.

PASTEUR'S WORK ON FERMENTATION AND ITS SIGNIFICANCE FOR PRESENT-DAY STUDIES IN BIOCHEMISTRY

By Prof. T. K. WALKER
Manchester College of Science and Technology

IN 1858 Louis Pasteur turned his attention to the behaviour of yeast and made observations which were to have far-reaching consequences for the study of intermediary metabolism. Now, a hundred years later, it seems a suitable moment to attempt an assessment of the extent to which his work and his ideas are still influencing the direction of inquiries in biochemistry.

Although trained as a chemist, Pasteur laid great stress on physiological function in its relation to the chemical activity of yeast. Liebig, in 1839, had affirmed that the change of sugar to alcohol and carbon dioxide is effected by what he termed a 'ferment', a nitrogenous, unstable substance, formed in plant juices containing sugar when such liquids are exposed to air. The ferment was supposed to act by imparting its instability to the sugar. Pasteur believed alcoholic fermentation to be entirely bound up with the metabolism of the yeast cell, and his attitude in this matter was thus in striking contrast to that of contemporary workers of the Liebig school. After much controversy, Liebig's point of view became untenable when Pasteur demonstrated the ability of a strain of yeast to multiply and to set up alcoholic fermentation in a medium containing only pure sugar, ammonium tartrate and mineral salts.

Moritz Traube[1], in 1858, formulated a general theory of fermentation which he elaborated further in 1877. In his opinion, the ferments of putrefaction, fermentation and decay were substances of definite composition, allied to proteins and produced by living cells. He conceived the idea of 'reduction ferments', able to transfer the oxygen and hydrogen of water to different parts of the molecule of the fermentable substance, and so effect that apparent intramolecular oxidation and reduction first postulated by Lavoisier. Traube also pictured 'oxidation ferments' which could take up free oxygen and transfer it to oxidizable molecules, or groups of atoms, to bring about such changes as the conversion of alcohol to acetic acid or of ammonia to nitrate. He thus anticipated to a remarkable extent modern views on the enzymes effecting oxidation and reduction in vital processes.

Those reduction ferments which Traube envisaged as responsible for the evolution of free hydrogen in certain fermentations, were later to be identified with such reducing enzymes as those of the butyric acid-producing organisms, studied by Pasteur in 1861. Pasteur demonstrated their inability to grow in air and thus showed that the maintenance of life is not necessarily dependent upon the taking-up of oxygen from the external medium. These forms of life became known as 'obligate' anaerobes.

In 1872 Pasteur showed that highly aerobic organisms, such as *Penicillium glaucum*, which normally could oxidize sugar completely to carbon dioxide and water, gave rise to an alcoholic fermentation when deprived of air. Conversely, when yeast, an anaerobic organism, was grown in strongly aerated sugar media, he observed that reproduction of cells increased considerably while production of alcohol diminished. In other words, if oxidation is suppressed by lack of oxygen, fermentation is enhanced. This inter-relation became known as the 'Pasteur reaction' or the 'Pasteur effect'. Thus, Pasteur defined two kinds of life, the aerobic and the anaerobic. Later[2], in 1875, in reply to criticisms formulated by Traube, he was to make the categorical statement that: "Fermentation is the consequence of life without air, life without free oxygen. More generally, every living thing, every organ, every cell which has the power to perform chemical work without making use of free oxygen forthwith brings about phenomena of fermentation". Again[3], in the "Troisième réponse à M. Berthelot" (1879), and in other publications, Pasteur reiterated his doctrine that all fermentation phenomena are manifestations of the life of the causative organism.

What Pasteur now needed, in order fully to maintain his theory, were quantitative results to permit mathematical definition of the real relations between the presence of oxygen and the rate of fermentation, measured by weight of alcohol formed by unit weight of yeast in unit time. However, experimental techniques of that period were inadequate for this purpose and the matter was left unresolved until, some forty-five years later, Meyerhof was able to furnish the necessary figures.

In 1897, two years after the death of Pasteur, the brothers Hans and Eduard Buchner separated from yeast the cell-free preparation, zymase, which could set up alcoholic fermentation. As a consequence, the theory that fermentation was simply the manifestation of the action of an isolable enzyme held the field for some years and Pasteur's opinion received little consideration. However, after 1906, when Harden and Young had revealed the complex nature of zymase and the occurrence of phosphorylation of hexose in fermentation, the teaching of Gowland Hopkins and the work of colleagues inspired by him brought growing realization of the functional importance of the hitherto uninvestigated intracellular enzymes. As early as 1913, Hopkins[4] anticipated, with surprising accuracy, developments which were not to occur until some ten to twenty years later. In the words of Dr. Marjory Stephenson[5], he pictured the cell as: "the seat of ordered chemical events controlled in the interests of growth and function", and it is evident that in this picture the enzyme theory of fermentation is harmonized with Pasteur's[5] teaching. The details came slowly, however, for even a partial explanation of the Pasteur effect had to await the outcome of an immense amount of further original work by many gifted investigators. These researches cannot even be outlined here, but the principal findings may be stated, for now, at last, they permit understanding of some of the ways in which the Pasteur effect may be regulated.

The quantitative experimental data, which Pasteur had been unable to furnish in substantiation of his theory, came in 1925 from a series of experiments brilliantly devised and performed by Meyerhof[6]. Using the Warburg micro-respirometer, he found considerable differences in the extent to which fermentative functions of the cells of different types of yeast (wine yeast, brewers' bottom fermentation yeast, bakers' yeast and wild yeast) were diminished when aeration was increased. His results proved a striking confirmation of Pasteur's views; in particular, in the case of wild yeast (*Torula* sp.) the fermentative and oxidative powers of the cell were seen to be almost completely interchangeable; the respiratory power of these cells was so high that in presence of oxygen they were to the extent of 75 per cent an oxidizing mechanism. In anaerobic conditions they were pure fermenters.

Returning to Harden's discoveries, it could be said that these provided the basis for the highly important studies of glycolysis in animal tissues, undertaken in the first half of the present century by Embden, Meyerhof, Parnas, Warburg, Dr. and Mrs. Cori and D. M. Needham, all of whom contributed to our now extensive knowledge of the reactions proceeding anaerobically from glycogen to lactic acid in muscle. Simultaneously, further work on alcoholic fermentation by yeast and other organisms was undertaken by many distinguished workers, including Harden, Robison, Fernbach, Neuberg, Nord, Kluyver and Meyerhof. In the period 1910–13 it had been rendered probable by the work of Neubauer and of Fernbach that pyruvic acid takes a key role in fermentation. Neuberg confirmed this view and discovered in yeast the enzyme carboxylase; this decomposes pyruvic acid to carbon dioxide and the acetaldehyde which, on reduction, affords ethyl alcohol. By 1933 it had become clear that glycolysis in muscle and fermentation follow a common pathway from the stage of hexose-6-phosphate to that at which pyruvic acid is formed from glyceric acid phosphate. Muscle tissue, however, lacks carboxylase, so here the pyruvic acid does not suffer decarboxylation but is reduced to lactic acid. Experiments of Lohmann, and of Meyerhof with Lohmann and with Kiessling, showed that the intermediates are produced in phosphorylated form down to the stage of phospho-enol-pyruvic acid, and the quantitative data relating to yeast fermentation were found to fit exactly into the fermentation equation of Harden. Almost full knowledge of the enzyme systems which mediate in the twelve steps between hexose and pyruvic acid has been acquired since 1933. Most of these enzymic catalysts have been isolated and purified. All the stages from fructose-1,6-diphosphate to pyruvic acid have been found to be essentially reversible. The final stage of fermentation, namely, reduction of acetaldehyde to ethyl alcohol, catalysed by alcohol dehydrogenase, is also reversible.

Since the Pasteur effect expresses the interrelations of the series of processes which take place during fermentation and respiration, it is now necessary to consider what evidence concerning the link or links between them has been afforded by the results of modern researches. The first suggestion that biological oxidations could be effected by coupled reactions with other enzyme systems had come in 1928 from Quastel and Wooldridge. In 1937 Szent-Györgyi[7] carried this idea a stage further by advancing the ingenious theory, backed by results derived chiefly from experiments with pigeon breast muscle, that the principal role of *l*-malate, fumarate and oxaloacetate in muscle is a catalytic one, that of carrying hydrogen between foodstuff and cytochrome. By combining Wieland's theory of hydrogen activation with Warburg's theory of activated oxygen and fitting Keilin's cytochrome into the system, Szent-Györgyi could now express the oxidation of a carbohydrate metabolite (the donator) as:

$$\text{Donator} \xrightarrow{2H} \underset{\text{(triose)}}{} \text{oxaloacetate} \rightleftharpoons \text{malate} \xrightarrow[\text{Activation by malic dehydrogenase}]{2H}$$

$$\text{fumarate} \rightleftharpoons \text{succinate} \xrightarrow[\text{Activation by succinic dehydrogenase}]{2H} WKS^{*} - O_2$$

* *WKS* = Warburg–Keilin system, by which hydrogen (or electrons) is donated to oxygen through the mediation of cytochrome and cytochrome oxidase.

This theory was not claimed as a complete explanation of carbohydrate oxidation in muscle, but it did constitute a notable advance in knowledge of the subject. Szent-Györgyi explained that the difference between glycolysis in muscle and oxidation lies in the fact that, anaerobically in muscle, hydrogen is transferred from triose to pyruvic acid, whereas in the presence of oxygen the hydrogen from triose is donated to oxaloacetate. Thus, to shift over from fermentation to oxidation requires nothing more than to carboxylate pyruvic acid and thus take the molecule out of the carbohydrate cycle and stabilize it as a catalyst. He suggested it was by carboxylation of pyruvic acid that Nature, in the course of phylogenetic development, changed to a process of oxidation the older and simpler process of fermentation. Szent-Györgyi[8] summed up in the statement: "According to this picture fermentation and oxidation thus represent alternate ways of metabolism. And this in part is probably the explanation of Pasteur's Effect".

While his conclusions were in course of publication there appeared the first of a most important series of papers by Krebs and colleagues in which the hypothesis of the tricarboxylic acid cycle was advanced and developed. Krebs[9] was able to show that the 4-carbon dicarboxylic acids in muscle are members of a more complicated cycle which starts from citric acid and ends in oxaloacetic acid.

After Werkman and Wood had detected the fixation of carbon dioxide by propionic acid bacteria, the synthesis of oxaloacetate from pyruvate and carbon dioxide was demonstrated by Krebs and Eggleston. This synthesis can occur in pigeon liver and in other cells from diverse sources. It is now believed that the citrate arises from union of oxaloacetate with acetyl co-enzyme A, the latter being derived from pyruvate. The Krebs cycle (tricarboxylic acid cycle) operates in living organisms of many kinds, and in animals it supplies much of the free-energy requirements of the cells.

Work by Warburg and by Keilin and Hartree twenty years ago showed that nearly the whole of the respiration of bakers' yeast is carried ultimately by cytochrome. Afterwards, claims were made that the earlier stages of respiration in yeast are those of the Krebs cycle, but there is also evidence for the view that the hexose monophosphate shunt pathway is followed.

The link between fermentation and respiration at the stage where pyruvate is carboxylated is only one of a number of inter-relations which give rise to the Pasteur effect. There is evidence that oxygen can suppress the action of several enzymes of the glyco-

lytic pathway (for example, phosphohexokinase or triosephosphate oxidase) by oxidizing —SH groups essential for protection of these systems, and Barron[10] cites other examples of interfering influences.

Reviewing all these developments one may ask: Can this theme still inspire new pioneering inquiries? There can be no doubt about the answer when we perceive among contemporary studies Lipmann's work on energy-rich bonds and on co-enzyme A, Calvin's achievements in photosynthetic chemistry and the discoveries of Krebs and Kornberg on the role of glyoxylate in a modified tricarboxylic acid cycle, for all these researches arise from earlier work on fermentation mechanisms. Co-enzyme A comes into action, for example, in the processes by which carbohydrate is converted into fat, while the glyoxylate cycle can account for the conversion of fat to carbohydrate in, for example, *Ricinus* seedlings. Finally, it may be noted that the nucleotide co-enzymes of fermentation have lately engaged the attention of Sir Alexander Todd and co-workers, in their brilliant studies of nucleotides.

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MECHANICS OF NORMAL MUSCULAR ACTIVITY

By Dr. R. J. WHITNEY

Medical Research Council Unit for Research on Climate and Working Efficiency, Department of Human Anatomy, Oxford

THE diverse aspects of the physiology of voluntary muscular activity have been recently reviewed[1]. A noticeable feature of current knowledge on muscle action is the often considerable gap that remains to be bridged between the comparatively simple properties of the artificially stimulated muscle preparation and the complex of activities which attends even the simplest muscular movement of the intact animal. Recently it has become possible to record, in greater detail than formerly, the forces and movements developed during the performance of normal, muscular tasks by the human subject. The special apparatus (force-analysis platform) used for obtaining this record has been described elsewhere[2]. In the interpretation of these records of normal muscular activity it has been found necessary to reconsider the subject of muscle mechanics, and to examine the possibility of applying the numerous results obtained with muscle preparations to an explanation of observations made on voluntary activity by the intact animal. This reconsideration has led to a conception of normal muscular activity which is, in many ways, different from that which is currently held or, at any rate, implied in modern text-books of physiology. This article is intended to indicate, as briefly as possible, the nature of this conception, the arguments on which it is based, and some of the uses to which it can be put to explain normal muscular activity. In general, what is said is concerned chiefly with the activity of skeletal 'power' musculature of the mammal.

It will be convenient to state, at the outset, the proposed hypothesis, and then to consider the arguments on which it has been based. The hypothesis states that the immediate result of the activation of a muscle via its normal nervous connexions is the production of an essentially oscillatory force. The frequency of the oscillation may vary in different muscles, but is of the order of 10 cycles per second in mammalian power muscles. The oscillatory response always has a component which does not vary, or which varies at a comparatively slow rate, in addition to the oscillatory component. The oscillatory component becomes more pronounced in stronger muscle actions. The apparent smoothness of muscle actions in the intact animal arises as a mechanical result of the application of the oscillatory force to masses—the masses being parts of the animal's body sustained against or moved in relation to external forces acting on the body parts. In the case of a man lifting or carrying a load, the mass of the load is added to that of the body parts also involved in the muscle action. The mechanical smoothing of the oscillatory driving force is never complete, so that normal muscular actions will always exhibit a small superimposed mechanical oscillation ('tremor') of the same frequency as that of the driving force. The value of this frequency is determined by an inherent property of contractile tissue (twitch-time). All the constituent fibres of a muscle are likely to participate in any sustained activity of the muscle, however slight this activity may be. Gradations of activity of the muscle are produced only partly by variations of the average rate of activation of the constituent muscle fibre. Variation of the degree of synchronization between the different muscle fibres is of comparable importance in the production of gradation of activity of the whole muscle.

It will be noted that the proposed hypothesis discards a number of views which have previously been expressed or implied with regard to the nature of muscular activity. In particular, tetanic responses of muscle are excluded as a normal feature. Tetanic responses of experimental muscle preparations have received considerable attention from muscle physiologists during the past fifty years or so, and it is still implied (for example, in text-books of physiology) that the nature of this response is of significance in the production of smooth action of muscle and in the gradation of muscular activity ('wave summation'). Lastly, the hypothesis rejects the view that muscle tremor arises as a property of sensory and neural mechanisms.

Tetanic activation of the individual muscle fibres of a muscle is precluded as a feature of normal muscular activity because direct observation of the discharge frequencies of the motor neurones which stimulate the fibres has shown that these frequencies would be inadequate to secure tetanic contraction. For tetanic contraction, artificial stimulation at frequencies greater than 50 impulses per second is required. Since Denny-Brown's[3] original observations, innumerable investigations have shown that the discharge frequency of the individual motor neurone rarely exceeds 30 impulses per second and is usually much less than this figure for normal, sub-maximal activity. For example, Bigland and Lippold[4], investigating the human gastrocnemius by electromyographic methods, observed maximum frequencies of between 25 and 35 per second during strong contractions of this muscle. These frequencies are much less than typical tetanic fusion frequencies of muscle preparations.

The basic response of the individual muscle fibre to stimulation via its normal nervous connexion is not, therefore, a tetanus but a twitch—that is, the response of the fibre to a single stimulating nervous impulse. The response is of an all-or-none character, and the force exerted (in an isometric twitch) or the shortening in length (in an isotonic twitch) follows a time-cycle which is completed, in the case of the constituent fibres of mammalian power muscles, in about 0·1 sec. (see, for example, Fulton[5]). The precise form of the force (or shortening)/time-curve during the activation-cycle of twitch has been discussed (see, for example, Sandow[6]). For purposes of computation the curve can be considered to approximate either to a harmonic or to a normal probability form. An appropriate harmonic form would be: Force (or shortening) $= A\ (1 - \cos\ 2\pi.t/T)$, where T is the duration of the activation cycle (about 0·1 sec.), t is any time during the activation cycle, and $2A$ is the peak force (or shortening). It will be obvious that no particular muscle fibre can complete more than $1/T$ (approximately 10) activation-cycles per second, and that for rates of activation less than 10 per second the particular fibre will exhibit discontinuous harmonic changes of force or shortening.

Completely synchronous activation of all the constituent fibres of a muscle (the number, in a human muscle, may exceed 1 million) is obviously not simply available in the intact animal. This generalization follows from two considerations: first, the conduction times between motor neurone and muscle fibre will vary; and secondly, complete synchronization of the motor neurone pool serving all the fibres of the muscle would be required. Since the motor neurone pool of a muscle may consist of several hundred motor neurones, spatially separated in the spinal cord, complete synchronization would be difficult to attain. For these reasons, the conception arises that the constituent fibres of a muscle must be activated, during voluntary contraction, in an essentially statistical manner. The muscle fibres are never, however, activated in a completely independent or random manner, because several hundred fibres (of a motor unit) are stimulated by a single motor neurone, and this will constitute a fixed synchronizing factor. Moreover, a variable physiological synchronizing factor probably exists, whereby the firing of the separate neurones of a motor neurone pool is progressively synchronized with increased afferent inflow to the spinal cord from the receptor organs of the muscle and from higher levels of the central nervous system (see, for example, Lloyd[7]).

The considerations raised in the preceding paragraphs suggest that the mechanical action exerted by a whole muscle at its origin and insertion on skeletal structures should be mathematically predictable by suitable summation of the mechanical actions exerted within the muscle by its constituent muscle fibres. Since the constituent mechanical action must vary with time, the total mechanical action must be predicted against time. The essential mathematical problem in the prediction is the summation of a large number of discontinuous harmonic changes, each of these changes being regarded as similar in all respects and the phase relations between the separate changes more or less randomly distributed. A formal mathematical treatment of this type of problem is not known to me, but a provisional solution has been attempted and has yielded the following results.

(*a*) The predicted total action of the muscle consists always of two components: a steady component which remains constant against time if the average rate of activation of the individual muscle fibre remains constant; and a continuous oscillatory component, the period of which is the activation cycle time (twitch time) of the individual muscle fibre. Thus, in mammalian power muscle, the oscillatory component will have a frequency of about 10 cycles per second.

(*b*) The magnitude of the steady component, for a muscle with a given number of constituent fibres, is directly proportional to the average rate of activation of the individual muscle fibre. The magnitude is not dependent on variation of the degree of synchronization between the fibres.

(*c*) The amplitude of the oscillatory component will be chiefly dependent on variation of the degree of synchronization between the fibres. The provisional solution suggests, for example, that the synchronization introduced by organization of a muscle into motor units of 100 muscle fibres per unit would give an amplitude 1,000 times greater than it would be if all the fibres were independent (asynchronous).

(*d*) To a lesser extent, the amplitude of the oscillatory component is also dependent on the average rate of activation of the individual muscle fibre. According to the provisional solution, the amplitude decreases with increase of rate of activation.

(*e*) It follows, from these mathematical results, that the peak force exerted by a muscle for a given average rate of muscle fibre activation would be progressively increased as the degree of synchronization between the fibres increased. The nature of gradation of muscle activity visualized by the hypothesis is summarized in Fig. 1.

The utility of these results in explaining certain aspects of normal muscular activity can be illustrated by reference to the following: (1) tremor during muscular activity; (2) muscular movement at uniform velocity; (3) the evaluation of 'static work' by muscle.

Since the original observations of Schäfer[8] there have been recurrent references to the tremor, of about 10 cycles per second, which appears to accompany muscular activity, particularly in mammals. This subject has recently been briefly reviewed[9]. Attempts have been made to account for this tremor as an oscillatory property of nerve–muscle servomechanisms. The hypothesis outlined above provides a much simpler explanation. Investigations of

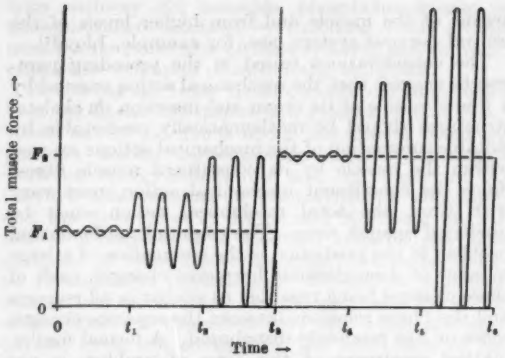

Fig. 1. Predicted effect of rate of muscle fibre activation, and of degree of synchronization between fibres, on the total muscle response due to statistical summation of responses of constituent fibres.
Two rates of muscle fibre activation, giving steady force components of F_1 and F_2, are represented. The effect on the oscillatory component and on the peak force is shown for three degrees of synchronization for each rate of activation. Time intervals t_2–t_3 and t_4–t_5 are for complete synchronization of fibres. The period of the oscillatory component remains constant throughout and equal to the twitch-time of the contractile tissue

postural tremor in man, using the force-analysis platform already referred to, indicate a progressive increase in amplitude of tremor with increased load on the musculature. This result is, of course, in agreement with the hypothesis.

The predominance of the oscillatory component in strong muscle actions, as predicted by the hypothesis, also provides a rational explanation of muscular movement at uniform velocity. It appears, from observations on man made with the force-analysis platform, that many muscular actions, such as postural readjustments and the lifting of weights, take place at almost uniform velocity. If muscle activation resulted in a steady force of the type observed in tetanized experimental preparations, accelerated movement of masses by the muscle would alone be possible. The dynamics of an oscillatory force applied to a mass shows, however, that all types of motion are possible, including uniform velocity. With the oscillatory force, a small tremor, of the same frequency as that of the applied force, is superimposed on the chief component of motion. The presence of such tremors, at frequencies of 10–12 cycles per second, has been confirmed for lifting actions carried out by man.

The oscillatory hypothesis of muscle action provides a very satisfactory conception of the nature of 'static work' by muscle. Static work is performed by a muscle when it maintains the position of a mass against an opposing external force. For example, postural muscles are required to perform static work against gravity if a certain posture is maintained and, in the case of a man holding a load against gravity, static work is performed by the muscles involved in the holding task. The evaluation of such static work in ordinary mechanical terms presents considerable difficulty if it is supposed that the task of maintaining position is performed by a steady force of the tetanic type (see, for example, Starr[10]). With a predominantly oscillatory muscle force no such difficulties arise. For example, if a mass M gm. is just sustained against gravity by an oscillatory muscle force of period T sec., then it follows from simple dynamics that the muscle performs ordinary physical work at the rate of $Mg^2T/2\pi^2$ ergs/sec. This treatment of static work may be employed to estimate the energy cost of standing upright in man, on the assumption that the whole body-mass is sustained against gravity by muscle action. If T is taken to be 0·1 sec., the estimated energy cost for a 70-kgm. man is 24 kgm.cal. per hour. This theoretical estimate is surprisingly similar to experimental values for the cost of standing obtained by indirect calorimetry, values of between 25 and 30 kgm.cal. per hour being observed by several authorities (for example, McCormick[11]).

These preliminary conceptions of the nature of normal muscular activity are being further developed, both theoretically and experimentally, and a fuller account of this work will be given elsewhere.

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THE TIDAL MODEL AT THE UNIVERSITY OF SOUTHAMPTON

By Prof. P. B. MORICE

THE tidal model of Southampton Water and the Solent at the University of Southampton was built and initially operated under a research contract from Caltex Services, Ltd., which are considering the construction of a new oil refinery off Hook in Southampton Water, just south of the mouth of the Hamble River. The refinery would be supplied from tankers lying in a specially dredged widening of the channel.

The object of the model investigation was to forecast the new tidal velocities resulting from the changed conditions due to dredging, in order to ascertain whether the bed would remain stable. This is of particular importance to the Southampton Harbour Board, since the existing channel has been made largely self-maintaining with only a relatively small amount of repeated dredging.

The position of the proposed dredged region so close to the southern end of Southampton Water precluded a model of Southampton Water only, since the tidal streams at this point are never stationary throughout the whole tidal cycle, and the flow in and out is far from rectilinear. The model was therefore limited at the next convenient boundaries—Hurst in the west and Gilkicker in the east (Fig. 1). This introduced a unique feature into

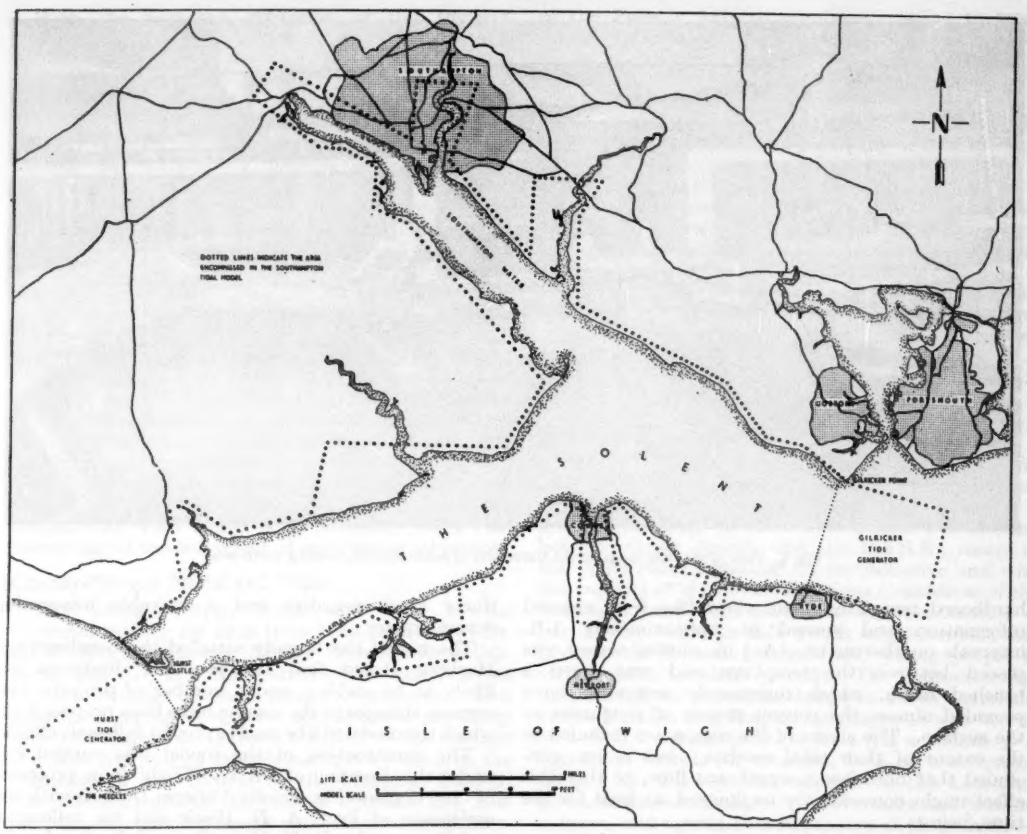

Fig. 1. Area covered by the tidal model of the University of Southampton; dotted lines indicate the boundaries of the model

the model (Fig. 2), since two tidal generators were required.

The horizontal scale of the model (1 : 1,250) was determined by the maximum dimension, that from Hurst to Gilkicker, some 20 miles in Nature, and the dimensions of the channel where the information was required. The vertical scale (1 : 100) enabled model tidal ranges of practical proportions to be used, while the exaggeration (12·5 : 1) did not cause excessive bed slopes. As a result of these choices, the velocity and times scales are fixed; namely, velocity-scale 1 : 10, time-scale 125 : 1. This latter gives a convenient tidal cycle period of 6 min. in the model

The tidal generators used in the model operate pneumatically, water being drawn into or released from tanks by changes in the tank air-pressure, which is controlled by valves allowing atmospheric leak into lines continuously extracted by high-speed pumps. The loads on these pumps are sufficiently steady to give good stability.

The tidal effects in the English Channel appear to result primarily from the excitation of a standing oscillation in the water mass extending from Land's End to Dover. The lowest frequency mode has a nodal line extending from Bournemouth to Cherbourg which, however, is distorted by the Earth's rotation to an effective nodal point inland of Bournemouth.

This system causes larger tidal ranges at the Gilkicker end of the Solent than at the Hurst end and greatly increases the range on the French coast. Superimposed upon the fundamental frequency at $12\frac{1}{2}$ hr. are many secondary effects (more than thirty components are required in a full harmonic analysis) the best known of which is the 'half-tide stand' or 'double high-water', known outside as well as inside the Solent. This gives Southampton its useful long slow flood and short fast ebb.

The main feature of the current system is a large flow back and forth in the Solent, with a relatively small quantity of water flowing in and out of Southampton Water and, so far as is known, no resultant circulation around the Isle of Wight, although this had been allowed for in the model by provision of an external connexion between the tidal generator tanks.

It is intended that the whole range from neap to spring tides should be produced by an electronic control system, but initial difficulties in the system made it necessary to obtain the information originally required by controlling the valves by motor-driven cams, prepared by a process of successive trial and error. For the present, the model operates on a maximum spring tide cycle only, which undoubtedly gives the maximum current velocities.

For the work in hand the model has been constructed with a hard bed. The bed was shaped by

Fig. 2. View of the tidal model of the University of Southampton, looking north-west

hardboard templates made as profiles from charted information and spaced at approximately 1-ft. intervals on the model. A ½-in. mortar screed was placed between the templates and was given a brushed finish, which fortunately seems to have provided almost the correct degree of roughness to the surface. The rivers of the region are included to the extent of their tidal reaches; but it was concluded that none has a significant flow, so that this effect might conveniently be ignored, at least for the time being.

The recording equipment at present used in conjunction with the model includes capacitor-transducer level recorders and a movable integrating current-meter.

The model has already satisfied the Southampton Harbour Board that the proposed dredgings are likely to be stable; and a number of projects concerning changes to the regime have been proposed, for which the model will be used to predict full-scale effects.

The construction of the model was carried out under the direction of Dr. W. Wright (now professor of civil engineering, Trinity College, Dublin) with the assistance of Prof. A. N. Black and his colleagues and Commander D. H. Macmillan, of the Southampton Harbour Board.

NEWS and VIEWS

Pembroke College, Cambridge: Prof. W. V. D. Hodge, F.R.S.

Prof. W. V. D. Hodge, who has been pre-elected master of Pembroke College, Cambridge, will take up his duties there in August. Prof. Hodge, who has held the Lowndean chair of astronomy and geometry in the University of Cambridge since 1936, has achieved an international reputation as a geometer, mainly through his creation and development of the theory of harmonic integrals. The importance of his pioneer work in this field was recognized by the award to him, last year, of a Royal Medal by the Royal Society. He is also the joint author of the important three-volume work, "Methods of Algebraic Geometry", a careful exposition of modern algebraic investigations into the foundations of this subject. In addition to leading a vigorous school of research, he has taken an active part in University administration, having served on the Council of the Senate and on the General Board of the Faculties. Last November he succeeded Sir David Brunt as physical secretary of the Royal Society.

Engineering Structures at the Imperial College: Prof. S. R. Sparkes

Dr. Stanley Robert Sparkes, who has recently been appointed to the new chair of engineering structures in the Department of Civil Engineering in the Imperial College of Science and Technology, London, graduated in the University of Bristol in 1932; he was awarded an industrial bursary by the Royal Commissioners for the Exhibition of 1851 and gained practical experience in the design of steel structures with Messrs. Dorman, Long and Co., Ltd. In 1935 he joined the staff of the Department of Civil Engineering at the Imperial College and has been attached to it ever since. At the outbreak of the Second World War he was seconded to the Ministry of Supply for duty in connexion with air-raid precautions in building structures, and in 1942 he spent some months in India as structural precautions adviser to the Government of India. In 1944 he returned to the Imperial College, where he was appointed reader in civil engineering in 1947.

With the post-war expansion of the Imperial College and its consequent need for a considerable building programme, the then rector, the late Sir Roderic Hill, found it necessary to appoint a full-time planning officer and Dr. Sparkes was seconded from his Department to that post in 1953. In 1955 the importance of this work was recognized by making him director of building works. In that position, Dr. Sparkes has carried considerable responsibility for the new buildings already completed—the Roderic Hill Memorial Building to house the Departments of Aeronautics and Chemical Engineering, large extensions to the City and Guilds College and the Royal School of Mines, and additions to the Students' Union—as well as for much bigger work now under construction or on the drawing-board. Dr. Sparkes's research work has been in the experimental study of problems relating to building and ship structures and in the correlation of stresses as calculated in the design office with those found by measurement on actual buildings. With the large constructional programme now in progress in connexion with the expansion of the College, Prof. Sparkes will have unrivalled opportunities for continuing this work which is so necessary for a real knowledge of the behaviour of engineering structures.

Corday-Morgan Medal and Prize

THE Corday-Morgan Medal and Prize of the Chemical Society for 1956 have been awarded to Dr. K. W. Bagnall (Atomic Energy Research Establishment, Harwell) in consideration of his contributions to the knowledge of the chemistry of polonium. This award, consisting of a silver medal and a monetary prize of 200 guineas, is made annually to the chemist of either sex and of British nationality who, in the judgment of the Council of the Chemical Society, has published during the year in question the most meritorious contribution to experimental chemistry, and who has not, at the date of publication, attained the age of thirty-six years. Copies of the rules governing the award can be obtained from the General Secretary of the Society at Burlington House, London, W.1. Applications or recommendations in respect of the award for the year 1957 must be received not later than December 31, 1958, and applications for the award for 1958 are due before the end of 1959.

The Comptrollership of the Patent Office

QUESTIONED in the House of Commons on March 18 by Mr. F. T. Willey regarding the professional qualifications held by the newly appointed Comptroller-General of the Patent Office, the President of the Board of Trade, Sir David Eccles, said that the officer appointed has a first-class record as an administrator, and that he considered that to be the qualification most urgently required at the present time. When Mr. Willey asked Sir David if he realized that Britain is now the only major country in the world without a man of high professional reputation at the head of its Patent Office, thus reversing a policy thirty years old, Sir David replied that he considered the office required men of administrative ability at the top, but that he has requested the new comptroller to give scientists on the staff better administrative opportunities, with the view of reverting next time to the old method of selection. In a written reply to Mr. P. G. Williams on the same day regarding the reasons for the appointment, Sir David said that the functions of the Patent Office extend beyond the administration of the Patents Acts to questions relating to trade marks, designs and copyright, as well as to other matters such as international negotiations and agreements about industrial property. About two-thirds of the staff of 1,200 of the Patent Office, costing about £1 million a year, is non-professional, and the size of the Office and the complexity of management problems due to pressure of work and shortage of scientific staff have made the appointment of a comptroller-general of particular importance at this time. After weighing carefully the many considerations, Sir David said he decided that the primary need is for a comptroller-general with qualities of leadership and wide administrative and managerial experience. The appointment would be without prejudice to the selection of future comptrollers-general from within the Office.

The Patent Office appointment was discussed in an editorial article in *Nature* of March 15, p. 725.

Exchange Visits with the Soviet Union

MR. IAN HARVEY, Under-Secretary of State for Foreign Affairs, replying to a question in the House of Commons on January 27, said that there is a growing exchange of visits by students and teachers between Great Britain and the U.S.S.R., many of the visits being organized on the initiative and with the support of the Soviet Relations Committee of the British Council. In particular, the Committee, in partnership with British youth organizations, has invited 300 Russian students and young people to visit Britain for short periods. The Committee has also offered an annual exchange of twenty students of the Russian and English languages as well as two British Council scholarships for a full academic year and short courses for teachers, both on a reciprocal basis. Mr. Harvey also referred to the assistance given in these exchanges by universities and training colleges, and agreed that expansion of these facilities might contribute to mutual understanding between the two countries in a manner acceptable to both Governments. On March 17, Mr. Harvey said that the Committee still awaits a definite answer from the Soviet Union, although some progress has been made with the arrangements for the visit of 300 Soviet students and young people and two groups have already visited Britain. Any delay with the other proposals is entirely due to the Soviet side.

New Reactor at Harwell

HAZEL, a new zero-energy reactor, is now operating at the Atomic Energy Research Establishment at Harwell. HAZEL (homogeneous assembly—zero energy) uses enriched uranium fuel in the form of a salt of uranium (uranyl fluoride) which is dissolved in the heavy water used as a moderator. The core of the reactor is a stainless steel cylinder (7 ft. high × 2 ft. in diameter) surrounded by a graphite reflector. The fuel solution is pumped into the cylinder from two nearby storage vessels. The system is controlled by adjusting the level of the fuel solution in the reactor vessel and by moving a vertical neutron-absorbing cadmium plate into the gap between the steel cylinder and the graphite reflector. Two cadmium plates similar to the control device are used as 'shut-off' rods: two additional 'shut-off' rods can be dropped vertically into the fuel solution in the reactor vessel. The reactor will be operated at a power of less than a watt and cooling is not necessary. HAZEL will be used to obtain basic nuclear information. An earlier system at Harwell, ZETR (zero

energy thermal reactor), was used to study solutions of nuclear fuel in ordinary water.

Atomic Energy

A number of questions on the peaceful uses of nuclear energy were asked by Mr. R. Mason in an adjournment debate in the House of Commons on March 20. Replying for the Government, Sir Ian Horobin, Parliamentary Secretary to the Minister of Power, said that from his inquiries at Harwell the question of the drift of leading scientists to the United States does not appear to be a very urgent problem at present. The storage and disposal of nuclear waste is a great trouble but not so far a major difficulty, and the present system of allowing the early decay to proceed and concentrate has not faced the Authority with any insuperable difficulties. The direct conversion to electricity from ZETA is a long way ahead and not at the moment a practical consideration. We now know a great deal more about the Wigner release, so that categorical assurance could be given that such an accident as that at Windscale could not recur. Moreover, the tendency is towards the use of higher temperatures and consequently, with graphite-moderated reactors, greater annealing of the moderator. The prospects of finding uranium in the United Kingdom are extremely slight. As regards secrecy restrictions, there is every evidence that Britain has been free from considerable difficulties which have arisen elsewhere, and he thought our approach has been sensible and moderate and also that we have found happier and more practical arrangements for partnership between the Authority and industry than some other countries. Considerable progress is being made in connexion with conventional stations, and it is thought that the economic difficulties of air-cooling might be sufficiently offset by savings in fuel transport when the stations are located nearer to coal. For nuclear power stations, the enormous usage of water renders the chance of economic advantage very slight. Sir Ian firmly defended the declassification and publication arrangements made in regard to ZETA and claimed that the matter had been handled well by the Authority, which was entitled to the confidence of the House and of the nation.

Human Sciences in Industry

Another stage in the development of psychology, sociology and related sciences in application to management, design and other industrial problems is marked by the decision of the Council for Scientific and Industrial Research to continue promoting research into the human problems of industry. In a written answer to a question in the House of Commons on January 21, Mr. H. Nicholls, the Parliamentary Secretary to the Ministry of Works, representing the Lord President of the Council, announced that the Council has set up a Committee on Human Sciences in Industry which will keep under review the development of the human sciences in relation to industrial needs, and will advise on the allocation of grants and on other means of promoting research in this field. On the side of the Department this Committee replaces the two former committees, on Human Relations in Industry and on Individual Efficiency in Industry, set up jointly with the Medical Research Council in 1953, agreement having been reached to replace them by separate committees reflecting the different interests of the two bodies.

A substantial flow of results is now coming from the research projects sponsored by those committees, on subjects ranging from psychological information theory applied to machine design to sociological aspects of technical change in the steel and other industries; the new Committee is expected to promote further applied research as well as more basic research in this field. Research and industrial interests are represented on the Committee, which has as chairman Mr. Lewis Wright (Amalgamated Weavers' Association), who is a member of the Council for Scientific and Industrial Research. The other members are Mr. P. W. S. Andrews (Nuffield College, Oxford); Mr. H. Briggs (Unilever, Ltd.); Prof. J. Drever (Edinburgh); Mr. E. Fletcher (Trades Union Congress); Prof. M. Gluckman (Manchester); Mr. H. G. Jones (Industrial Group, U.K. Atomic Energy Authority); Mr. H. G. Nelson (English Electric Company); Prof. E. A. G. Robinson (Cambridge); Miss B. N. Seear (London School of Economics); and Dr. A. T. M. Wilson (Tavistock Institute of Human Relations). The secretary is Mr. R. G. Stansfield.

Supply of Teachers in Schools and Technical Colleges

Replying for the Government in an adjournment debate on science teachers and National Service on March 17, Mr. R. Carr, Parliamentary Secretary to the Ministry of Labour and National Service, agreed most strongly with what Mr. W. Stones, Mr. E. Short and Dr. H. King had urged as to the importance of a sufficient number of adequately staffed technical colleges. Nevertheless he explained that, whereas technical colleges already have substantial help in their staffing problems from the existing arrangements for deferment, the even more favoured treatment of the secondary schools is a matter of deliberate policy, largely because of their greater need. In 1957 there were about 12,250 graduate teachers of mathematics and science in the schools and at least 300 unfilled vacancies. Between 1957 and 1964 the number of children more than fifteen years of age in the schools is expected to rise from about 250,000 to nearly 500,000, and even if the present net annual increase of 500 in science and mathematics teachers is maintained, sixth-form classes in those subjects are likely to be overcrowded. This is the first reason why the Government is concerned to do nothing that might interrupt the flow of such teachers into secondary schools. The second reason is that it is considered desirable that teachers in a technical college should have had some industrial experience, and that accordingly any concession to benefit technical colleges should also be given to jobs requiring similar qualifications in industry. This was recognized by the Willis Jackson Committee; the Government has moved a considerable way towards the more general and broader extension of deferment recommended by that Committee, but believes it is important to maintain a preference in favour of the schools. A third reason lies in the needs of the Services, which rely upon National Service to supply skilled scientific man-power until scientists can be recruited on a long-term basis. As regards the current position in the technical colleges, there was a net increase in full-time teachers of about 900 in 1956; for 1957 this was expected to be more than 1,000; and for 1958, about 1,400.

Technical Teacher Training

For the past ten years or so the technical teacher training colleges in Bolton, Huddersfield and London

have had only some 350 places available in all. This number is now being increased by more than 60 per cent, and substantially higher grants are to be paid to students, in order to attract the right quality and quantity of candidates from those already settled in industry and commerce. Candidates are accepted as either 'private' or 'recognized' students for a course of one academic year. The latter pay no tuition fees, are offered free board and lodging in the college hostels and are eligible for maintenance allowances. To be accepted a candidate should normally have reached his twenty-fifth birthday, should possess a degree, Higher National Certificate or equivalent qualification and should have some commercial or industrial experience. Further information can be obtained from the Director, Huddersfield Training College, Queen Street South, Huddersfield.

Royal Society Expedition to Southern Chile

THE Royal Society has announced that plans are being made, in co-operation with the Royal Society of New Zealand, to send a small expedition to southern Chile in September. Dr. Martin Holdgate, Zoology Department, University of Durham, has been appointed organizer, and Mr. G. A. Knox, Canterbury University College, New Zealand, and Dr. E. J. Godley, director of the Botany Division of the New Zealand Department of Scientific and Industrial Research, will also take part. The University of Chile has expressed its interest and also hopes to send representatives. It is intended that this expedition should be exploratory and preliminary to a proposed Commonwealth expedition to the South Pacific area.

Many genera and species of animals and plants occur both in South America and in New Zealand and Tasmania. The precise extent of this relationship remains uncertain, however, although its elucidation is clearly important for an understanding of biological evolution and of the past history of the Earth's surface. The fauna and flora of the world are now changing so rapidly through man's activity that it is likely that within another generation precise information about the natural distribution of animals and plants will be unobtainable, so that further research is needed urgently. A great deal of work has been done on the biology of New Zealand and its neighbouring islands, but by comparison southern Chile has been little studied. The present expedition's first visit will therefore be to the western hills of the island of Chiloe, where there are extensive tracts of dense evergreen rain-forest, and it will then proceed southward towards the Straits of Magellan. Ecological and geological studies will be made in the three areas it is proposed to visit, and peat samples will be collected from mountain bogs and lowland lakes in connexion with pollen analyses, from which it is hoped to learn something about past climatic and vegetational changes in the region.

Bardsey Observatory

THE report of Bardsey Bird and Field Observatory for 1956 (Eglwysfach, near Machynlleth, Mont.: W. M. Condry, Hon. Secretary, 1957) contains details of many successful observations and developments. In a year of unusually heavy migration twice as many birds were ringed as in any previous season; more than a thousand birds were ringed at the lighthouse at night. Among the more unusual birds recorded were the melodious warbler, *Hippolais polyglotta*, and the greenish warbler, *Phylloscopus trochiloides*. During the year a visit was paid by botanists from the University College of North Wales, who surveyed the island's flora and prepared a species list, which is included in the report. The Observatory is open to visitors, particularly during the months of May, June and July. Further information can be obtained from W. M. Condry, Eglwysfach, Near Machynlleth, Montgomeryshire.

University News: London

THE following appointments have been made: Dr. C. P. Whittingham, assistant director of research in botany in the University of Cambridge, to the University chair of botany tenable at Queen Mary College; and Dr. A. R. Flint, consulting civil engineer, to the University readership in structural steelwork tenable at the Imperial College of Science and Technology.

Announcements

DR. G. A. H. ELTON, at present reader in applied physical chemistry at Battersea College of Technology, has been appointed director of research of the British Baking Industries Research Association, Chorleywood. Dr. Elton's research has been mainly in the field of colloid chemistry. He was awarded the degrees of Ph.D. and D.Sc. of the University of London for work on this subject and for a number of papers which he has published in the field of rheology.

THE Sixth Conference of the British Agricultural History Society will be held on April 10 and 11 at the Yorkshire (W.R.) Institute of Agriculture, Askham Bryan, York. Further information can be obtained from the Secretary of the Society at the Department of Agriculture, Parks Road, Oxford.

THE Scottish Group of the Nutrition Society is holding a symposium on "Nutrition and Climatic Stress" at the Hannah Dairy Research Institute, Kirkhill, Ayr, on April 26, when papers will be read on both human and animal nutrition. Further particulars may be obtained from Dr. J. Davidson, The Rowett Research Institute, Bucksburn, Aberdeenshire.

THE Scottish Branch of the Science Masters' Association is to hold its annual general meeting during April 10–12, in the University Chemistry Department, King's College, Aberdeen. The programme includes lectures, exhibitions and visits to places of scientific interest. Further information can be obtained from D. W. Menzies, Aberdeen Academy.

THE Ergonomics Research Society is holding a conference on "Problems of Training" at the University of Bristol during April 13–16. Further information can be obtained from Dr. O. G. Edholm, Department of Human Physiology, M.R.C. Laboratories, Holly Hill, Hampstead, London, N.W.3.

THE Operational Research Society is to hold an open conference at the Old Swan Hotel, Harrogate, during May 21–22. The conference will afford to representatives of commerce and industry an opportunity to discuss current applications of operational research. The main theme of the conference is "Aids to Decision Making". Further information can be obtained from the Honorary Secretary of the Operational Research Society, 3rd Floor, 20 Albert Embankment, London, S.E.11.

NATIONAL PARKS IN BRITAIN

THE eighth annual report of the National Parks Commission*, which includes confirmation of the Designation Order for the Brecon Beacons National Park, brought the number of National Parks established to ten, covering an area of 5,250 square miles. With the confirmation of the Commission's orders designating areas in the Gower Peninsula and in Lleyn and the Quantock Hills the first areas of outstanding natural beauty designated under Section 87 of the Act have been established, but the Minister's decision on the Surrey Hills area is awaited. Formal proposals for the designation of other areas on the Dorset coast and its hinterland, in Cornwall and Cannock Chase and on the Northumberland coast have been made to the local authorities concerned. The Commission also reports that though there has been no general relaxation of the restriction on capital expenditure, the Minister has enabled Park planning authorities to proceed with some tree planting and construction on car parks. Some quiet progress is reported in other matters also, such as the provision of cheap holiday accommodation for visitors with young families, anti-litter campaigns and caravan sites; but it is clear that, although in some areas progress has been made in the removal of misunderstandings and unreasonable criticism of the handling by the Park committees of applications for the supply of electricity, the Commission is still not entirely happy about the administrative arrangements resulting from the Minister's failure to insist on the provisions of the Act. There is also still room in all Park areas for the publicity activities which the Park Planning Board have been extending.

New rights of way were dedicated along some ten miles of the Pennine Way, leaving some 5¼ miles outstanding, but progress in making footpath agreements for the approved Cornwall North and South Coast Paths remains slow. With the acquisition of some nine new miles along the Pembrokeshire Coast Path, 25 miles remain to be completed, and some 44 miles of new rights of way are still required for the Offa's Dyke route. Increasing attention is being given to publicity by the Commission itself, both for the Country Code and in attempts to make the National Parks more widely known and create public awareness of what is being done under the National Parks Act. Evidence was given to the Royal Commission on Common Land in which the National Parks Commission recommended that any body or person empowered to sanction change of use of commons, or to extinguish common rights, or to draw up schemes of management for commons, should, before any action were decided, receive representations from the local planning authority and, where National Parks or areas of outstanding natural beauty were concerned, from the National Parks Commission. The hope was expressed that common land would be given over to rotational cropping only where it was clearly in the national interest to do so, and that in forestry schemes landscape values would be protected so far as possible by the consultations already indicated. Management schemes designed to enhance the beauty of the landscape and preserve to the public the recreational use of the land were favoured, and the National Parks Commission stated that it would strongly oppose, save in cases of the most exceptional national importance, the use of common land for mineral extraction. An approach was again made, but without success, to the Chancellor of the Exchequer for provision in the Finance Bill, or in a separate Bill, for the reimbursement from the National Land Fund of expenditure on National Parks.

The outstanding feature of the Commission's report this year is once again that of development, and especially those represented by the proposals for a nuclear power station at Trawsfynydd. The Tryweryn Valley Water Scheme (in which the Liverpool Corporation withdrew entirely the Conway part of its scheme against which statutory and amenity bodies had petitioned) and developments at Milford Haven are going ahead, but the Commission affirms the view that large-scale industry should only be sited in National Parks in cases of over-riding and inescapable national necessity and in the absence of alternative sites elsewhere.

* Eighth Report of the National Parks Commission for the Year ending 30th September, 1957. Pp. iv+66+8 plates. (London: H.M. Stationery Office, 1958.) 5s. 6d. net.

RECRUITMENT OF TEACHERS

SIR EDWARD BOYLE, Parliamentary Secretary to the Ministry of Education, replying for the Government in a debate on February 14, on the recruitment and training of teachers, said that he did not think that unemployment among teachers in the nineteen-sixties was to be feared. The cornerstone of the Government's educational policy was that the first priority should be a reduction in the size of classes, and although Sir Edward did not discuss other objectives such as compulsory part-time day release and raising the school-leaving age to sixteen still required for full implementation of the 1944 Act, he pointed out that decision on the timing of these objectives would be governed by, *inter alia*, the supply of teachers. The debate was a little too early for him to give the full picture, but over the seven years that ended in 1956 the increase in the number of teachers in maintained schools was about 6,500, but this now seemed to have dropped to just over 5,000. About 900 more training teachers should be going into the schools in 1958 than in 1957 and a further 700 in 1959. Recruits to teaching without professional training remained fairly steady at 700 a year, but there was a marked increase in graduates taking up first appointments in schools —from about 1,800 in the year ended March 31, 1956, to about 2,600 the following year. There had, however, been marked decline in the number of married women returning to teaching, from 2,300 in 1951–55, to just over 1,000 in 1956. Nearly 600 more teachers retired in 1957 than in 1956 and it seemed also that more women teachers resigned than in previous years. On this net annual increase of 5,000, if the present ratio of 21·5 pupils per full-time

teacher was maintained in senior classes, the average size of junior classes could only fall to a little more than 31 by 1962. Major changes in policy, however, must await adequate information and consultation.

Sir Edward Boyle affirmed that the Government was absolutely committed to the three-year training course announced last summer, and much planning was proceeding to secure the best results from this advance. He entirely agreed that the training colleges must be up to date in curriculum and discipline, and he thought that conditions were improving. The standard of many libraries was excellent and the regime much more flexible. On the technical side, after referring to the Willis Jackson report, Sir Edward said that recent figures for recruitment of technical teachers were encouraging: an increase of 1,000 appeared probable in 1956–57 and for 1957–58 a total increase of 1,400 was anticipated. After stressing the need for close co-operation with industry, Sir Edward said that in principle the Willis Jackson Committee's recommendations regarding pre-service courses in the three technical training colleges had been accepted and that Dr. Willis Jackson had accepted the chairmanship of a new standing committee on the supply and training of technical teachers which had just been established.

After dealing in some detail with the assessment training grants for former members of the Regular Armed Services, Sir Edward referred to the question of specialist teachers, particularly of mathematics and science. Although the 12,250 graduate teachers of mathematics and science in the schools was an increase of 1,750 over the past five years, this was insufficient to maintain the staffing standard in these subjects. The demand for such teachers was expected to increase by 40 per cent between now and 1962, but the actual increase was estimated at only 27 per cent. In the long term, the best hope of avoiding overcrowded classes in mathematics and science in sixth forms during the coming years lay in a large increase in mathematics and science graduates from the universities and in an increased attractiveness of teaching as a career. Sir Edward hoped that industrialists would remember that it was in their own interest that science and mathematics should be well taught in the schools. The training colleges could help in some measure and had been asked to bear in mind the importance of mathematics and science in planning their courses and selecting students for training, and in the past five years the number of training college students taking main courses in mathematics had doubled; in science the number had risen by 75 per cent.

THE LEVERHULME TRUST

THE first report of the Leverhulme Trust on the Leverhulme Research Awards (pp. 72. London: The Leverhulme Trust, 1957) gives a record of the research awards, 1933–47, covering 273 made under the general scheme at a total cost of £130,299. Up to and including 1957, 612 were made at a total cost of £276,548, of which 580 costing £255,787 belong to the general scheme. The record is arranged in three sections: arts and humanities; natural sciences (including mathematics and medicine); and social science. In each section awards are listed chronologically by year and alphabetically for each year, giving the subject of research and relevant publications. There is an index of names and list of abbreviations for periodicals. The record is preceded by a historical note by Sir Hector Hetherington describing the circumstances which led to the establishment of the scheme, reviewing briefly its working and development and noting some of the problems encountered. The scheme was conceived mainly to help senior academic workers to complete their research projects, but it has never been restricted to the universities: many awards have been made to members of the staffs of national museums and galleries for study at home and abroad, and the primary purpose of the scheme continues to be to offer opportunities for periods of study and research which are not provided or inadequately provided by the official systems.

In general, the method used is to make good to the recipient any loss of income incurred by taking a period of study-leave and to meet such special expenses of the programme as could not be covered by other resources. Normally, the award, which has from the beginning been of no fixed amount, consists of two parts: a personal grant to replace earnings foregone, and a grant towards the special expenses of the programme.

The primary test of eligibility for a personal grant is that some loss of earnings should be incurred in undertaking the programme, and in general the Trust requires that the awards should be made for a significant period of time—at least three months, with an upper limit of two years. It is not at all concerned to pay the expenses of delegates to conferences or to other national or international gatherings. Recently the Trustees, however, have approved four further smaller schemes. In 1953 two 'European' awards were offered to young postgraduate scholars to meet the cost of a year of study in one or more centres of learning in Continental Europe. Two further schemes were developed for two or three years postgraduate study in a British university for candidates nominated by universities and university colleges in Africa and the West Indies. Four awards a year are also offered to graduates of British universities who wish to work for one or two years in the West Indies or in Africa, while finally three awards are offered each year to enable young graduates of certain major art schools to have a year of continuous study abroad, one of these awards being in the field of industrial design.

These recent policies are still regarded as experimental, and while awards have been made in almost every field of study, the Advisory Committee's working rule that no one project could be supported to the extent of more than 15 per cent of the resources available in any year has excluded a few very expensive schemes. The main area of concentration has been in age-group 40–60, but the spread extends from 27 to 80, and Sir Hector refers to the notable advantage of the private trust that it may more readily employ some of its resources as venture-capital to support a promising but more than ordinarily hazardous programme. It is intended to issue further reports at five-yearly intervals.

THE EUROPEAN NUCLEAR ENERGY AGENCY

THE European Nuclear Energy Agency was established to further the development of the production and uses of nuclear energy for peaceful purposes through co-operation among the participating countries, which include the United Kingdom and all the member countries of the Organization for European Economic Co-operation. It came into being on February 1, and the text of the Statute and related instruments was published as a White Paper on February 4*. The Agency will operate through a Steering Committee for Nuclear Energy and such other commissions and working parties as may be required, and the Governments of Canada and the United States are invited to associate themselves with the work of the Agency. Where appropriate, the Agency will promote the formation of joint undertakings for the production and application of nuclear energy for peaceful purposes, endeavouring to secure the participation of as many countries as possible, and it will do all in its power to ensure that joint undertakings as well as participating countries are regularly supplied with the necessary raw materials.

The Agency is instructed to examine jointly with the Steering Board for Trade measures to achieve the maximum freedom of international trade in products of interest for the production and application of nuclear energy and will encourage the development of research, promoting, where appropriate, agreements for the joint use of research installations and the creation of joint research establishments, and also the exchange of scientific and technical information between participating and associated countries. It is also to promote the development of training in matters relating to nuclear energy so as to assist in meeting the demand for scientific and technical personnel in this field, both by encouraging co-operation to secure the full use and development of existing training facilities in competent national institutions and by encouraging legislation to secure the protection of public health and prevention of accidents in nuclear industry, the most efficient use of patented inventions and to provide for third-party liability and insurance against nuclear risks. The Agency is required to establish a security control to ensure that the operation of joint undertakings and the materials, services and equipment provided by the Agency or under its supervision do not further any military purpose, and the organization of this control is detailed in a special Convention, the text of which is included in the White Paper. The Convention provides for a central bureau assisted by a director and administrator and technical officers, in particular a group of international inspectors, as well as for a tribunal of seven independent judges appointed for five years.

The Statute also provides for close collaboration with the European Atomic Energy Community (Euratom), with which an agreement is to be made defining the arrangements under which the control established by the new Convention is to be carried out in Euratom territory. Agreement may also be made with the International Atomic Energy Agency for the same purpose.

* Atomic Energy. Miscellaneous No. 2 (1958): Decision of the Council of the Organization for European Economic Co-operation establishing a European Nuclear Agency and Convention on the Establishment of a Security Control in the Field of Nuclear Energy, Paris, December 20, 1957. Pp. 19. (Cmnd. 357.) (London: H.M. Stationery Office, 1958.) 1s. net.

STANDARD FREQUENCY TRANSMISSIONS FROM THE UNITED KINGDOM

A LIMITED programme of transmissions of standard radio frequencies was started in 1950 from the Post Office station at Rugby under the call sign *MSF*. This was extended in 1953 to the provision of a continuous service on the three frequencies of 2·5, 5 and 10 Mc./s. with periods of modulation by a 1,000 c./s. tone and by 1 c./s. pulses (see *Nature*, 172, 529; 1953). From the start these transmissions have been monitored at the National Physical Laboratory, which has just published a new edition of a pamphlet entitled "*MSF*—Standard Frequency Transmissions from the United Kingdom". This gives full technical details of the current programme, including reference to the additional transmission which is made for one hour each day on a frequency of 60 kc./s., and which provides a ground-ray service over a wide area inside the skip-distance of reception on the higher frequencies. This transmission has proved so valuable that the carrier wave of the 16 kc./s. *GBR* telegraph transmitter is now also controlled from the *MSF* standard although it is not yet regarded as part of the regular service.

The new pamphlet (obtainable free on application to the Director, National Physical Laboratory, Teddington, Middlesex) also announces that the *MSF* frequencies are now based on the resonant frequency of the caesium atom. Provisionally, the value of 9, 192, 631, 830 cycles per second has been adopted for this. This frequency is a fundamental physical constant, free from the small corrections and uncertainties associated with astronomical time. The precise value of the frequency is based on the value of astronomical time for 1955. Some years must pass before the astronomical and atomic units can be compared to the full accuracy attained by the atomic clock because astronomical time must be averaged over a long period to eliminate small errors and uncertainties of measurement. If any corrections prove necessary in years to come, they can readily be made and, therefore, will not restrict the accuracy already available.

The *MSF* frequencies and modulations are maintained to $\pm$ 5 parts in 10^9 but are monitored to $\pm$ 1 part in 10^{10}. Continuous measurements on the transmissions are made at the National Physical Laboratory, 120 km. distant from Rugby. The results, which are published monthly in *Electronic and Radio Engineer*, are given only to $\pm$ 1 part in 10^9 to allow for slight transmission and propagation errors, but even more precise average values can be used when steps are taken to eliminate these errors.

WATER RESOURCES OF BRITAIN

A BROADSHEET, "Policy for Water" (No. 418; January 27, 1958), issued by Political and Economic Planning, attempts to give the background to the problem of water resources and supply by sketching the history and development of the water industry and other organizations concerned with the exploitation, disposal and conservation of water. Current economic and technical problems of supply and demand and pricing are then reviewed, including the need for more information, and the Broadsheet next discusses the two main administrative problems: first, the urgent need for a comprehensive rationalization of local water undertakings; and secondly, the need for greater co-ordination in all matters concerning water supply, fisheries, drainage, etc.

Pending the publication of the reports of the sub-committees appointed by the Central Advisory Water Committee, Political and Economic Planning concludes provisionally that the water resources of Britain are likely to be adequate to meet foreseeable demands, but that much new capital must be expended if water is always to be available in adequate quantity or appropriate quality wherever it is needed. The Broadsheet points out that while water of high quality is essential for drinking purposes, low-grade water will often serve industrial needs, and it is desirable that increasing attention should be given to this aspect and that we should not continue to draw on our relatively scarce resources of pure water for purposes for which water of inferior quality would do equally well.

There are far too many authorities. A radical rationalization of the water-supply industries is long overdue and is essential for substantial progress, although the basic technical economic problems of water supply can only be served if adequate capital is provided. Procedures laid down in the current Water Acts are long and intricate, and further measures may be required to overcome the natural unwillingness of many authorities to acquiesce in their own extinction within a reasonable time.

DIATOMS FROM EQUATORIAL INDIAN OCEAN CORES

THE appearance of the ninth volume of the reports of the Swedish Deep-Sea Expedition 1947–1948* completes Dr. R. W. Kolbe's trilogy on the diatoms from the equatorial zones of the most traversed oceans. The material here reported consisted of twenty-three cores selected from those obtained from the Indian ocean by M/S *Albatross* under the leadership of Prof. Hans Pettersson.

The cores were taken with a Kullenberg sampler and some of them from a depth exceeding 5,000 m. were more than 11 m. in length. As the complete examination of so large a mass of material would be impracticable, three samples were usually taken from each, namely, one from the deepest layer, one from the uppermost layer, and one midway between. The cores chosen for this study had been shown by preliminary survey to contain diatoms, and after submitting the material to the usual acid-cleaning technique it was mounted for microscopical examination.

The cores selected were obtained from seven geographical regions: (1) Java, (2) East Indian Ocean, (3) Ceylon, (4) Maldives, (5) West Indian Ocean, (6) Seychelles, (7) African coast.

In this way samples were examined from inshore positions (68 m. depth) to positions of great oceanic depth of more than 5,000 m.

By his use of the term 'diatom assemblage' Kolbe has rendered a great service in stressing the relation, or lack of it, between the silica unicells of the sediments and the diatom flora living in the column of water immediately above them. This abyssal assemblage differs from the planktonic and benthonic populations from which it is derived not only in a reduced number of species, but by their differing numerical frequencies. This assemblage is therefore not a natural facies of living organisms but belongs to a thanatocoenosis. Further, the physico-chemical selection which is brought to bear upon dead and dying diatoms during their slow journey through great oceanic depths to the sea floor is largely responsible for the marked uniformity observed in the diatoms over wide regions of the ocean floor. Dr. Kolbe's researches have also led him to observe a marked similarity between the diatom assemblages of the Atlantic[1], Pacific[2] and Indian oceans, and that the most frequent species are not confined to any one area, and that they differ only by their relative frequencies in the different areas. For example, *Coscinodiscus nodulifer*, *Ethmodiscus* (fragments) and *Nitzschia marina* are the commonest and most frequent species in all three equatorial oceans. Five others, *Hemidiscus cuneiformis*, *Thalassionema* sp., *Coscinodiscus excentricus*, *Coscinodiscus lineatus* and *Coscinodiscus africanus*, are common to the sediments of the three areas, but differ in their relative frequencies in the different oceans. These eight species constitute what Kolbe describes as the dominant abyssal assemblage.

One of the most interesting problems in diatom occurrence in oceanic cores is that concerning *Ethmodiscus rex* (Wall.) Hendey. This diatom, the largest known, lives or has lived in the three equatorial oceans and enormous deposits of it have been recorded from various parts. It is one of the most common diatoms in the equatorial sediments of the three oceans. For example, an area of oceanic ooze some three thousand miles long by twenty wide, consisting almost entirely of *Ethmodiscus*, has been reported between Guam and Luzon. Kolbe also has found evidence of considerable deposits of this species in the Indian and Atlantic Oceans—yet records of living specimens in the plankton have been rare.

Kolbe seeks to explain the discrepancy between the scarcity of *Ethmodiscus rex* in the plankton and its abundance and frequency in oceanic sediments, by combining three possible hypotheses: (1) dysphotic habit, explaining the rarity of the species in plankton

* Göteborgs Kungl. Vetenskaps- och Vitterhets-Samhälle. Reports of the Swedish Deep-Sea Expedition 1947–1948. Vol. 9: Sediment Cores from the Indian Ocean. No. 1: Diatoms from Equatorial Indian Ocean. By R. W. Kolbe. Pp. 50+4 plates. (Göteborg: Elanders Boktryckeri Aktiebolag, 1957.) 15 Sw. kr.

samples taken by usual techniques (Karsten's hypothesis); (2) periodicity of short duration of mass reproduction (Hendey's hypothesis); (3) resistance to corrosion (Kolbe's hypothesis). Kolbe is of the opinion that the great accumulation of *Ethmodiscus* fragments in certain limited areas of the sea floor may be explained by the complicated relations between currents, sea-floor topography, size and form of sediment particles, all of which might result in a constant deposition of particles of certain properties in certain circumscribed areas.

Thus *Ethmodiscus* fragments within a certain size range might be constantly deposited at a given place, and so form *Ethmodiscus* beds, while other particles less dependent on slow currents might be distributed in a very different way.

Those who have tried to understand something of the relation between oceanic deposits, and the distribution of the living plankton populations that contribute to their formation, will find Dr. Kolbe's stressing of the differences between thanatocœnesis and biocœnesis of the greatest interest.

It seems that these differences must be influenced by the following factors (among others):

(1) Chemical erosion, as stressed here by Dr. Kolbe.

(2) Rate of fall. Here the wide range in sinking rate of fragments derived from the one species *Ethmodiscus rex*, determined experimentally by Dr. Kullenberg, seems especially significant.

(3) Speed and direction of sub-surface currents. Recent physical observations, albeit in a very different part of the world, show that their speed may be much greater than Dr. Kolbe felt entitled to assume (cf. ref. 3).

(4) Extreme periodicity in local swarming of certain species of plankton diatoms, as postulated by Hendey[4]. Probably most plankton workers of long experience can recall odd instances supporting this view, but not, unfortunately, with regard to *Ethmodiscus* itself. The relative lack of samples from its apparent habitat is probably quite sufficient to account for this.

These four factors are very well presented in Dr. Kolbe's paper, but it is felt that yet another may be important:

(5) What might be termed the biological part in the breakdown and decay of plankton diatom frustules. The ingestion of frustules or fragments by mesoplankton animals may be repeated several times before they reach bottom, with the further probability of considerable bacterial action both before and after ingestion (cf. ref. 5). This may well be of great importance in determining which members of the biocœnosis remain recognizable in the thanatocœnosis.

One minor correction to Dr. Kolbe's paper is necessary. The record of dense swarms of *Ethmodiscus* in the Bay of Bengal does not occur in Collingwood's paper of 1868, in *Transactions of the Royal Microscopical Society*, the reference quoted, but in the discussion following the reading of the paper (*Quart. J. Micr. Sci.*, 115; 1868), as Hendey has explained. The paper has now become a rarity, and some of the surviving separates do not include the discussion. The actual observations concerning *Ethmodiscus* in the Bay of Bengal seem to have been made by Dr. Wallich in 1851 and 1857.

The number of benthonic diatoms (112 taxa) observed in the material was 56 per cent of the total and was far greater than in the sediments of the Atlantic and Pacific Oceans. This is accounted for by the number of cores taken close to land. The high number of benthonic forms taken from the vicinity of the Seychelles archipelago, however, presents several interesting problems, as the cores were taken at great depth and far from the African mainland. It is suggested that their presence indicates that the whole district may have formerly belonged to a shallow sea and that its floor might have sunk to its present considerable depth at a not very remote period. The benthonic diatoms are, with very few exceptions, provided from thirteen of the twenty-three cores examined. The cores from the Ceylon, Maldives, and East Indies areas provided but six species. The paucity of *Triceratium* species, particularly those belonging to the *T. favus* group, and of *Mastogloia* and *Amphora* in the Java cores is surprising, as these genera are well represented in the area. The occurrence of species of *Stictodiscus*, usually considered to be extinct, at widely separated areas is significant. Mann[6] showed in his work on the diatoms of the Philippine Islands that the genus is well represented there and it may be that isolated pockets of these species have persisted since the Tertiary. Those in the African cores were found at depths varying from 4 cm. to 10 m.

Dr. Kolbe is to be congratulated upon completing this very considerable task without yielding to the temptation of making a host of new species out of the wide range of variants that the abyssal assemblage offered.

N. Ingram Hendey

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SOLAR ACTIVITY AND RADIO COMMUNICATION

By R. NAISMITH

Radio Research Station (Department of Scientific and Industrial Research), Slough

SEVERAL years ago the period 1957–58 was selected as the International Geophysical Year in the expectation that it would coincide with a period of high solar activity. This long-term prediction has proved quite successful, since it is actually coinciding with the highest period of solar activity which has occurred within the past two hundred years. The success of this long-term prediction, however, must be considered in relation to a comparatively large number of failures which make anyone who is aware of the difficulties involved reluctant to make long-period predictions until more is known of the causes of the variations.

There are, however, particular parts of the sunspot cycle which can be more accurately predicted than others for intermediate periods up to twelve months.

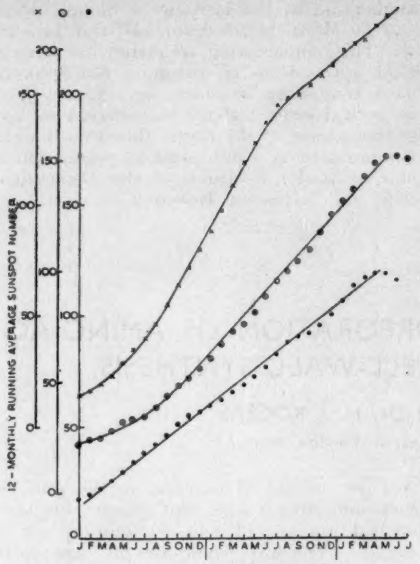

Fig. 1. ●, 1935–37; ⊙, 1945–47; ×, 1955–57

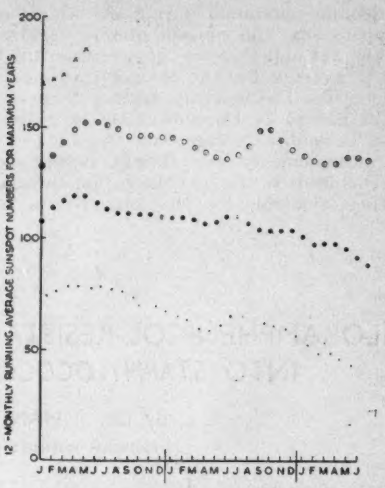

Fig. 2. •, 1928–30; ●, 1937–39; ⊙, 1947–49; ×, 1957–

These predictions are very useful in relation to radio communication, etc. This occurs, for example, during the rising period of each cycle, particularly when the maximum tends to be high. The last three cycles, which are good examples of this, are shown in Fig. 1. The prediction is associated with the linear rise, which may persist for periods of eighteen months or more. The end of this part of the current cycle is near, but there are features which may be associated with the present and future period of the current cycle to which attention should be directed.

In Fig. 2 the data plotted in Fig. 1 have been extended to cover a period of about two and a half years after the maximum of the cycle, and it will be noted that there is a general correspondence which may be used by a forecaster to estimate values for some time ahead. This is by no means a universal happening; but if the higher level of the present cycle should be maintained, the sunspot numbers during the next six months will be higher than those at present forecast by any organization making regular forecasts.

In consequence of this, it is probable that higher radio-frequencies may be used for communication during the first half of 1958 than those forecast. The association of radio-communication conditions by way of the *F*-region of the ionosphere, as denoted by the variations in the noon critical frequencies (*fF*2) of that region as measured at Slough, and the solar activity as denoted by sunspot numbers, is shown in Fig. 3. This covers two and a half sunspot cycles, and this is the whole period for which the ionospheric measurements are available. Although neither the solar nor ionospheric index is perfect, they are both convenient for this purpose of comparison, and the agreement, even in some detail, reflects the close association of these two quantities when average values are considered.

This leads naturally to some useful data for radio-communication purposes. It is important, for example, to be able to distinguish between those radio-frequencies which may be used for long-distance radio communication by way of the *F*-region and those frequencies which, apart from a residual amount of scattering, will penetrate the ionosphere and will not reach great distances. For this purpose, use can be made of the sunspot data extending back over the years indicated in the first paragraph.

When interpreting the radio data, account must be taken of a well-known seasonal variation in the noon values of *fF*2 as recorded at Slough. This shows a

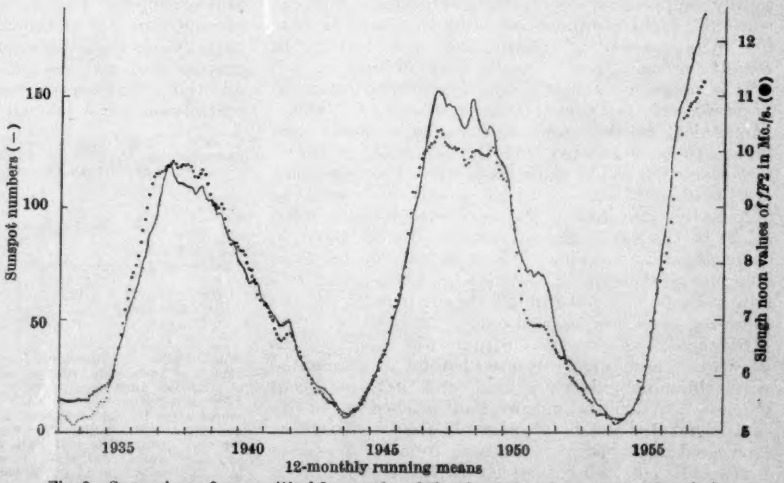

Fig. 3. Comparison of noon critical frequencies of *F*-region (●), and sunspot numbers (–)

very definite maximum during the winter months. It happens that the sunspot number for December 1957 was 244 and therefore greater than the twelve-monthly average for the maximum period of the present cycle. The monthly median value of *fF2* at noon at Slough in December was 15·2 Mc./s., the highest December average value recorded at Slough since measurements were begun twenty-six years ago. This leads to the conclusion that the maximum frequency available for the longest-distance radio communication at the latitude of Slough would be close to 50 Mc./s. at noon for half the days in the month. This 'demarcation' frequency has some useful practical applications in planning radio communication in temperate latitudes.

The work described above was carried out as part of the programme of the Radio Research Board, and this communication is published by permission of the Director of Radio Research of the Department of Scientific and Industrial Research.

CHLORAMPHENICOL-RESISTANT INCORPORATION OF AMINO-ACIDS INTO *STAPHYLOCOCCI* AND CELL-WALL SYNTHESIS

By Dr. J. MANDELSTAM and Dr. H. J. ROGERS
National Institute for Medical Research, London, N.W.7

THE incorporation of radioactive amino-acids into the protein of bacteria, whole tissue cells and various sub-cellular fractions has been widely used as a method of studying the biosynthesis of proteins. In this context, 'protein' is usually defined, in practice, as the residue remaining after extraction with hot trichloroacetic acid and organic solvents. The appearance of radioactive amino-acids in this residue has often been accepted as a measure of protein synthesis. However, Gale and Folkes[1] examined the situation in which a single radioactive amino-acid was supplied to *Staphylococcus aureus* and found that, although there was no net increase in protein, the label was incorporated steadily for at least 2 hr. Furthermore, the incorporation of single amino-acids was much more resistant to chloramphenicol than protein synthesis. The authors therefore concluded that incorporation of a labelled amino-acid was not necessarily an indication of protein synthesis and suggested the possibility of an exchange reaction between the labelled molecules and the corresponding residues within the protein.

This type of reaction does not appear to be general, for other work has shown that, in *Escherichia coli*, the incorporation of glycine and leucine is almost totally suppressed by growth-inhibitory concentrations of chloramphenicol[2], and the same is true for incorporation of methionine and leucine in *Bacillus cereus* (Urbá, personal communication).

It is noteworthy that amino-acid incorporation in *Staphylococci* is particularly resistant to chloramphenicol in the case of those amino-acids now known to be associated with the cell wall. It therefore seemed possible to us that, when the organisms are incubated with a single amino-acid such as glycine or glutamate, the incorporation observed might be the result of synthesis of cell wall which, in *Staphylococci*, contains five amino-acids (glycine, alanine, glutamic acid, lysine and serine) and two amino-sugars[3]. Accordingly, experiments of the following type were carried out.

Staphylococcus aureus, Strain 524 55/*SC*[4] was grown in a casein hydrolysate medium supplemented with thiamine, nicotinic acid and 0·5 per cent glucose[5]. When the culture had reached a density of 1 mgm. dry weight of cells/ml., the bacteria were harvested and washed twice with 0·05 *M* phosphate buffer, *p*H 7·0, and suspended at a density of about 1 mgm. dry weight of cells/ml. in the same buffer solution containing 0·5 per cent glucose, 400 μgm./ml. of labelled amino-acid and 70 μgm./ml. of chloramphenicol. The suspension (150 ml.) was shaken at 35° C. for 60 min. in a one-litre conical flask. A portion of the cells (obtained from 15 ml. of the suspension) was treated with hot trichloroacetic acid and organic solvents and then dried[2]. This will be referred to as 'protein' and contains both the cell wall and the true cell proteins. The rest of the bacteria were washed, suspended in water at a density of 10 mgm./ml. and disrupted by shaking with glass beads for 15 min. Cell wall was separated, washed with water, treated with ribonuclease and trypsin followed by digestion with pepsin[3]. The cell-wall material was then washed several times with water and then with acetone and ether and finally dried. The supernatant from the disrupted cells after removal of cell wall, together with the water washings, was treated with an equal volume of 10 per cent trichloroacetic acid and left at 2° for 30 min. The precipitate was extracted with hot trichloroacetic acid and organic solvents and dried. This will be referred to as the 'true protein' fraction. Radioactivity of samples was measured at infinite thickness in a thin end-window Geiger–Müller counter. In some of the experiments involving glycine, samples of cell wall and 'true protein' were hydrolysed, the glycine isolated by paper chromatography and its specific activity determined[2]. In addition, samples of 'protein' and cell wall were hydrolysed for 4 hr. with 4 *N* hydrochloric acid at

Table 1. Distribution of Radioactivity incorporated into Protein and Cell Wall by *Staphylococci* in the presence of Growth-inhibitory Concentrations of Chloramphenicol

	Specific activity of cell fraction (counts/min.)			Increase in cell wall (per cent)
Amino-acid	(1) Cell wall + protein	(2) Protein	(3) Cell wall	
Glycine	145	3	662	85
DL-Glutamic	17	3	65	33
L-Lysine	16	2	61	30

Washed cells were incubated for 1 hr. in phosphate buffer containing glucose (0·5 per cent), chloramphenicol (70 μgm./ml.) and 300 μgm./ml. of a labelled amino-acid, namely, glycine-1-^{14}C, or DL-glutamic acid-1-^{14}C or L-lysine (uniformly labelled). The specific activities of the amino-acids in the incubation medium were, respectively, 350, 665 and 1,350 counts/min./μ*M*. The cell fractions isolated were: (1) 'protein' (containing cell wall and 'true' cell proteins); (2) 'true protein'; and (3) cell wall. Specific activities of these fractions are given as counts/min. measured at infinite thickness

100° and hexosamines determined after treatment with a cation exchange resin ('Dowex 50') according to Boas[6].

Table 1 shows the type of results obtained when glycine, DL-glutamate and L-lysine labelled with carbon-14 have been present singly in the incubation medium. The greatest amount of cell-wall synthesis took place with glycine. It will be noted that, irrespective of the amount synthesized, virtually all the radioactivity was associated with the cell-wall fraction; the 'true protein' fraction contained only a trace of radioactivity. Omission of chloramphenicol from the incubation mixture did not substantially affect the results except that the radioactivity of the 'true protein' fraction was slightly increased.

The question now arises whether the incorporation of an amino-acid into the cell wall is the result of exchange between the amino-acid in solution and the corresponding residues in the wall, or whether it is due to an increase in the mass of the cell wall. In a typical experiment the specific activity of the glycine isolated from the cell wall indicated that an increase of 66 per cent should have occurred in the total amount of cell wall. This is in quite good agreement with the increase found in cell-wall mass (60 per cent). Using the hexosamine content of the 'protein' as a measure of the amount of cell wall indicated an increase of 52 per cent.

It thus seems certain that, in intact *Staphylococci*, cell-wall synthesis occurs in the presence of growth-inhibitory concentrations of chloramphenicol and that this is sufficient to account for the incorporation of glycine, glutamate and lysine into the 'protein' fraction. The incorporation of amino-acids into the 'protein' fraction of disrupted *Staphylococci* described by Gale and Folkes[7] has not been examined by us in this way, and it is, of course, possible that some process of exchange occurs in such preparations which does not occur in the intact cell.

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'INTERCALATED' INTERNODES IN NERVE FIBRES

By Dr. L. LUBIŃSKA

Nencki Institute of Experimental Biology, Warsaw

IN surveying teased nerve fibres from peripheral nerves of laboratory animals one sometimes encounters internodes which are much shorter and thinner than others on the same fibre. Such internodes were first observed by Rénaut[1] in peripheral nerves of horses and asses. Rénaut considered their existence as a proof that the nerve fibres grow not only from the central end but also by intussusception of new internodes and called them 'short intercalated segments'.

The short internodes probably represent a phase of restitution after a local inflammatory process described by Gombault[2] in lead poisoning and in many disorders of various origins. The process attacks individual internodes, or even portions of internodes, leading to granular destruction of myelin, and proliferation of Schwann cells in the affected region. The continuity of axoplasm is, however, usually preserved and the fibres do not degenerate. The denuded axoplasmic cylinder eventually becomes re-myelinated and recovers; the only permanent trace left is the shortness of newly formed internodes. Gombault calls this condition 'névrite segmentaire periaxile'.

The short internodes, vestiges of a local neuritis which struck some fibres at an earlier period, offer thus an uncommon opportunity to study the reorganization of a stretch of adult fibre after selective destruction of myelin. A short description of 'intercalated segments', based on an analysis of some forty peripheral fibres from fifteen cats, is therefore presented here.

The 'intercalated' segment always starts at a node and terminates at a node (Fig. 1). Sometimes a single short internode is present, more often the intercalated segment is formed by a succession of several short internodes. Various degrees of maturation are

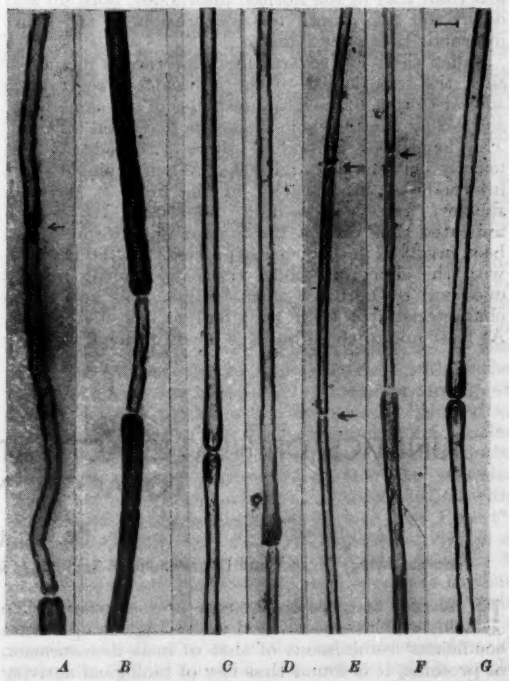

Fig. 1. 'Intercalated segments'. Proximal ends uppermost. Arrows indicate nodes between short internodes. Scale, 20μ. *A* and *B*, fibres fixed in osmium tetroxide; *A*, portion of an intercalated segment and junction with the distal normal internode; *B*, single short internode; *C* and *G*, normal portions of a fresh fibre containing four short internodes; *D*, *E* and *F*, consecutive portions of the intercalated segment

Table 1. Normal and Short Internodes in Fibres of Cats. Successive Internodes of each Fibre in Proximo-distal Order. All Dimensions in Microns

Fibre from	Internode	Total diameter	Axon diameter	Thickness of myelin	Location of the nucleus at	Length of the internode
Peroneal	I normal	19·8	11·7	4·0	880	1,750
	II short	13·1	8·7	2·2	170	320
	III short	13·3	8·7	2·3	230	455
	IV short	13·1	9·0	2·1	175	345
	V short	14·1	9·5	2·3	—	510
	VI short	14·6	10·3	2·2	—	230
	VII normal	19·5	11·5	4·0	910	1,850
	VIII normal	19·8	11·7	4·0	860	1,700
Ventral root	I normal	20·8	11·7	4·5	—	1,150
	II short	17·5	11·7	2·9	210	400
	III short	17·7	11·7	3·0	210	400
	IV short	17·3	11·2	3·0	200	380
	V normal	20·7	11·7	4·5	—	—
Median	I normal	18·7	11·7	3·5	—	—
	II short	13·3	7·7	2·8	140	300
	III short	13·7	7·7	3·0	230	480
	IV short	13·3	7·3	3·0	140	305
	V short	13·7	8·0	2·9	160	320
	VI normal	19·0	11·5	3·7	—	1,300
Peroneal	I normal	18·0	11·7	3·1	—	1,310
	II short	10·0	7·0	1·5	40	85
	III normal	18·0	11·5	3·2	—	—
Peroneal	I normal	12·0	6·0	3·0	—	
	II normal	12·0	6·0	3·0	—	1,200
	III short	6·0	4·0	1·0	—	50
	IV normal	12·0	6·0	3·0	—	—

encountered. In some internodes the myelin is very thin and the amount of cytoplasm of the Schwann cell is increased. In others the myelin is much thicker and the excess of Schwann cell cytoplasm has already disappeared. The diameter of the axon is less than that of the normal internodes, both up and down the fibre, until the maturation of the short internode is fairly advanced.

When there are several short internodes in succession, the total length of the intercalated segment is similar to that of normal internodes of the same fibre, suggesting that a whole internode had been affected. The length of individual short internodes varies usually between 300 and 500μ. When a single short internode is 'intercalated' in the fibre, it is much shorter, rarely exceeding 50–150μ. Its length indicates that only a fraction of an internode had been involved in the neuritic process. At the junction with the short internode, the neighbouring normal ones end by bulbs of normal dimensions and shape characteristic of their proximal or distal location[3]. At least one of these bulbs is newly formed, showing that the end of the normal portion of the fibre has been reorganized.

The dimensions of normal and short internodes in several fibres are shown in Table 1.

The nucleus of the Schwann cell is always located in the middle of the short internode. This seems to indicate that the metabolic activity connected with the deposition of myelin extends in the Schwann cell symmetrically over a length of some 150–250μ on each side of the nucleus. If the denuded portion of axoplasm is longer, several Schwann cells adhere to it and the process of myelination starts in each cell, presumably by the mechanism elucidated by Geren[4] in developing fibres. Eventually several internodes are formed on a stretch occupied previously by one internode only. The length of new internodes is similar to that found by Vizoso and Young[5] in adult fibres regenerating after Wallerian degeneration and in fibres of very young animals.

In the early stages of restitution the nodes between successive short internodes are adumbrated simply by the interruption of myelin. The axon remains cylindrical throughout. It is only in the course of further maturation that the constriction of the axon at the node appears and the juxta-nodal bulbs develop.

The similarity in the behaviour of Schwann cells after a selective destruction of myelin and after Wallerian degeneration suggests that during the latter process it is also the breakdown of myelin, and not that of axoplasm, that determines the initial proliferation of Schwann cells. During the recovery the presence of the naked axon in the neurilemmal tube leads to a similar course of re-myelination and to similar morphological outcome in both conditions.

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KINETICS OF HEAT INACTIVATION OF RIBONUCLEIC ACID OF TOBACCO MOSAIC VIRUS

By Dr. WILLIAM GINOZA
Atomic Energy Project and Department of Radiology, School of Medicine, University of California at Los Angeles

In marked contrast to the case of deoxyribonucleic acid, which is inactivated with a high-temperature coefficient[1] reminiscent of that of heat denaturation of proteins, it is found that loss of biological activity of the infectious ribonucleic acid of tobacco mosaic virus occurs with a moderate heat and a negative entropy of activation at neutral *p*H. The results are interpreted to mean that inactivation is a consequence of a single hydrolytic break in the phosphodiester backbone of the polynucleotide chain. The present findings, considered in the light of the known properties of this ribonucleic acid, indicate support for a single-stranded molecule.

Tobacco mosaic virus ribonucleic acid was obtained[2] by the method of Fraenkel-Conrat and Williams[3] from the common strain, *U*-1. Series of 0·1-ml. aliquots of a solution containing 1–2 mgm. of nucleic acid per ml. in 0·1 *M* phosphate buffer, *p*H 7·15, are

heated for various periods at temperatures between 37° and 65° in a thermostatted water-bath. Heated samples and unheated controls are diluted to 10–30 μgm. per ml. in 0·067 *M* phosphate buffer, *p*H 7·0, and assayed on *Nicotiana glutinosa*, employing 20 half-leaves or more for any given sample. Under our conditions of assay, the lesion count response is linear with concentration of ribonucleic acid up to 30 μgm. per ml.

Results of a typical single experiment in which aliquots from the same nucleic acid preparation were heated at two different temperatures are shown in Fig. 1. It is seen that the plots of the logarithm of the surviving fractions versus time of heating are linear. While the error involved is inherently great in assays of this type, the results of numerous experiments indicate no systematic deviation from first-order kinetics. Heat inactivation of viruses in general follows a course of first-order kinetics; numerous examples, including that of tobacco mosaic virus, are cited and discussed by Pollard[4]. The plot of the logarithm of the first-order rate constants versus the reciprocal of the absolute temperature is linear over the temperature-range 37°–65° (Fig. 2). The heats of activation ($\Delta H^{\ddagger}$) and entropy of activation ($\Delta S^{\ddagger}$) calculated from these data for the heat treatment leading to the loss in infectivity is about 19 kcal. per mol. and − 19·5 entropy units, respectively. Bacher and Kauzmann[5] obtained values which are very close to these from their experiments on the kinetics of hydrolysis of yeast ribonucleic acid. They followed the course of hydrolysis by titration.

From the moderate value of $\Delta H^{\ddagger}$, it would appear that inactivation of tobacco mosaic virus ribonucleic acid does not involve disordering of secondary structure maintained by a large number of weak bonds, such as H-bonds. The negative entropy of activation observed is interpreted here to reflect the formation of a cyclic phosphate triester intermediate in the activated state of the molecule. It indicates that the activated molecule has less degrees of freedom because of the added bond between the phosphorus atom and the 2-OH of the ribose. A cyclic intermediate of this kind has been postulated by Fonó[6]

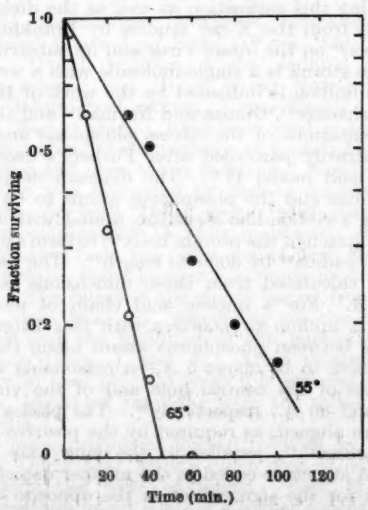

Fig. 1. Survival curves of tobacco mosaic virus ribonucleic acid heated at *p*H 7·15 in 0·1 *M* phosphate buffer

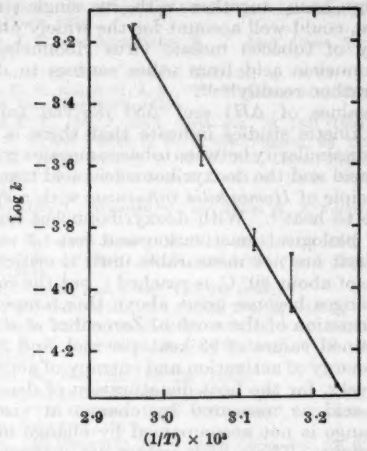

Fig. 2. Temperature dependence of the rate of inactivation of tobacco mosaic virus ribonucleic acid by heat at *p*H 7·15 in 0·1 *M* phosphate buffer. The rates at 37°, 42° and 47° were estimated from single point inactivation curves

and Brown and Todd[7] to explain the ease of hydrolysis of ribosephosphate as compared with that of deoxyribosephosphate. Bacher and Kauzmann[5] interpreted in this manner the kinetic data they obtained for the hydrolysis of yeast ribonucleic acid.

The first-order kinetics observed in the heat inactivation of tobacco mosaic virus ribonucleic acid most likely means that a hydrolytic cleavage of only one phosphodiester bond is sufficient to inactivate the molecule. In this connexion, Gierer finds that the decrease in the mean molecular weight of tobacco mosaic virus ribonucleic acid is a simple exponential function of time of treatment with ribonuclease, suggesting that this molecule is single stranded[27]. Since hydrolysis of ribosephosphate bonds is involved in both cases, it follows that a single break in the polynucleotide chain by heat must also cause an exponential decrease in the mean molecular weight.

On the other hand, Thomas[3] finds that an enzymatic (deoxyribonuclease) breakdown of deoxyribonucleic acid is characterized by a lag, the molecular weight decrease being contingent on coincident rupture of two phosphodiester bonds, one on each of two chains and occurring within the distance of two nucleotides. Breaks occurring at greater distances from each other are not believed to result in scission of the deoxyribonucleic acid molecule because the intervening H-bonds are sufficiently strong to prevent separation of the two strands. Biological inactivation of bacteriophage labelled with phosphorus-32 has been studied by Stent and Fuerst[9]. In this case also the loss in biological activity is a consequence of breaks in phosphodiester bonds. A first-order kinetics is observed in this case as in that of tobacco mosaic virus ribonucleic acid, but their results are explicable only in terms of coincident scission of *both* strands of the deoxyribonucleic acid molecule. They conclude that where only a single break is incurred, the molecule is still capable of functioning. From these parallel observations, we are led to favour the view that tobacco mosaic virus ribonucleic acid is a single-stranded molecule. The comparative ease of hydrolysis of ribosephosphate

bonds by heat, together with its single-stranded structure, could well account for the widely observed tendency of tobacco mosaic virus ribonucleic acid and ribonucleic acid from other sources to depolymerize rather readily[10-13].

The values of $\Delta H^{\ddagger}$ and $\Delta S^{\ddagger}$ derived from the present kinetic studies indicate that there is also a marked dissimilarity between tobacco mosaic virus ribonucleic acid and the deoxyribonucleic acid transforming principle of *Hemophilis influenzae* with respect to response to heat[14]. With deoxyribonucleic acid, the rates of biological inactivation and loss of viscosity due to heat are not measurable until a critical temperature of about 80° C. is reached; but the rates for both changes become great above this temperature. In confirmation of the work of Zamenhof *et al.*, Doty has obtained values of 93 kcal. per mol. and 220 e.u. for the energy of activation and entropy of activation, respectively, for the heat denaturation of deoxyribonucleic acid as measured by change in viscosity[1]. This change is not accompanied by change in molecular weight. These high values are interpreted in terms of the breaking of about fifteen successive pairs of H-bonds in the Watson–Crick structure in the activated state which precedes the irreversible collapse of the molecule. The same high order of $\Delta H^{\ddagger}$ and $\Delta S^{\ddagger}$ can be estimated from the kinetics of the loss both in the transforming activity and in the viscosity of *H. influenzae* deoxyribonucleic acid from the data of Zamenhof *et al.* Both changes are found to commence at the same temperature[14]. Thus, the kinetic studies suggest that heat inactivates deoxyribonucleic acid by a process akin to protein denaturation, whereas it inactivates tobacco mosaic virus ribonucleic acid by a breakage of a covalent bond with a direct loss in molecular weight.

The following properties of tobacco mosaic virus ribonucleic acid further point to its difference from the Watson–Crick structure: (1) the purine-to-pyrimidine ratio deviates from unity; Knight's data show the ratio[15] is 1·2; (2) the sign of birefringence is positive in the case both of the free nucleic acid[16] and of the intact virus[17], indicating that the bases are aligned parallel to the long axis of the molecule, while the sign is negative in the case of deoxyribonucleic acid[18]; (3) tobacco mosaic virus ribonucleic acid reacts readily with formaldehyde[19] and is adsorbed by active carbon[20]. Both of these reagents do not affect deoxyribonucleic acid because the bases with which they presumably interact are inside the coaxial helix. The bases of the ribonucleic acid molecule must be in some situation easily accessible to these reagents. Thus, the two important requirements—base composition and conformation—upon which the specific hydrogen-bonding of the two-stranded helix of deoxyribonucleic acid depends are shown not to be satisfied by tobacco mosaic virus ribonucleic acid.

The present comparative studies of the kinetics of degradation by heat and enzymes and of other physical and chemical properties indicate that tobacco mosaic virus ribonucleic acid is quite unlike that of the Watson–Crick double helix. These studies are of particular interest because tobacco mosaic virus ribonucleic acid and deoxyribonucleic acid molecules both share a common biological function, namely, that of self-replication. This interest is reflected in the current investigations dealing with the question of whether synthetic polyribosenucleotides can form copolymers truly resembling the structure of deoxyribonucleic acid[21,22]. There appears to be no evidence,

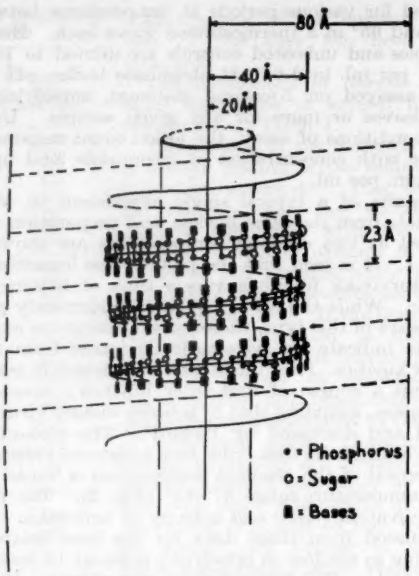

Fig. 3. Schematic representation of a single-strand nucleic acid helix of 40-A. radius (ref. 29) in position within the tobacco mosaic virus rod. The spacings of the purine and pyrimidine bases, ribose rings and phosphorus atoms with respect to the helix are made approximately to scale. There are about 50 bases per turn of the helix, aligned parallel to the longitudinal axis of the virus particle. A central hole of 20-A. radius extends the length of the particle. A protein matrix of 60-A. radius or thickness (80-A. radius of the virus less 20-A. radius of the hole) is composed of a few thousand equivalent sub-units set in a helical array about the axis of the rod (ref. 23)

however, to suggest that any of the naturally occurring ribonucleic acids, including that of tobacco mosaic virus, is double stranded.

Franklin *et al.* suggest that one possible model of tobacco mosaic virus ribonucleic acid involves a single strand coiled the length of the virus rod in structural conformity to the protein helix[23]. A diagram of the nucleic acid can be drawn (Fig. 3) embodying this suggestion as well as the dimensions obtained from the X-ray studies by Franklin[24] and by Casper[25] on the intact virus and its substructures. That the strand is a single molecule with a weight of about 2 million is indicated by the work of Hopkins and Sinsheimer[26], Ginoza and Norman[13] and Gierer[27]. The orientations of the ribose, phosphate and bases are arbitrarily patterned after Furberg's deoxyribonucleic acid model II[23]. The diagram depicts the ribose rings and the phosphorus atoms to be in one plane as a ribbon-like structure wound with a pitch of 23 A. (pitch of the protein helix[24]) to form a cylinder of 40-A. radius[29] by 3000-A. length[30]. The length of a helix calculated from these dimensions is about 33,000 A. For a nucleic acid chain of molecular weight 2 million to conform with this length, the spacings between phosphorus atoms along the helix would have to be about 5 A.—a reasonable value[31]. The radii of the central hole and of the virus are 20 A. and 80 A., respectively[25]. The planes of the bases are aligned, as required by the positive sign of birefringence[16,17], parallel to the long axis of the helix. A structure coiled in the manner depicted can account for the sign, which is the opposite of that reported for other ribonucleic acids[32] and deoxyribonucleic acid[18]. The 'open' arrangement of these

bases is consistent with their known reactivity with formaldehyde[19] and adsorbability on active carbon[20]. The fact that this nucleic acid in cold solution will retain its positive birefringence[16] as well as its biological activity for some days following its isolation from the virus suggests that there is some kind of force stabilizing the helix. Under the present scheme, a single-chain polymer free in solution may be stabilized, as Gierer also suggests, by hydrogen bonds between turns of the helix. Such bonding would require or lead to some contraction of the coiled molecule, because the 23-A. spacings between turns would be too wide for the bridging. This type of interaction, however, is not expected to be comparable in magnitude or specificity with that involved in the internucleotide hydrogen-bonding of the deoxyribonucleic acid molecule. In the intact virus particle it appears unnecessary to invoke hydrogen-bonding to stabilize the helix because the protein matrix would be expected to perform this function.

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DEPENDENCE OF THE OBSERVED OXYGEN EFFECT ON THE POST-IRRADIATION TREATMENT OF MICRO-ORGANISMS

By TIKVAH ALPER and Dr. N. E. GILLIES

Medical Research Council Experimental Radiopathology Research Unit, Hammersmith Hospital, London, W.12

TWO commercially available complete media, 'Oxoid Blood Agar Base' (10 gm. 'Lab Lemco', 10 gm. 'Oxoid' peptone, 5 gm. sodium chloride, 15 gm. agar/l.) and 'Difco Bacto Nutrient Agar' (3 gm. 'Bacto' beef extract, 5 gm. 'Bacto' peptone, 15 gm. 'Bacto' agar/l.), have been used in investigations concerning the sensitivity of *Escherichia coli, B* to ionizing and ultra-violet radiation. Survival after irradiation was estimated by plating samples, after each dose, on both 'Difco' and 'Oxoid' plates, and counting colonies after 15–24 hr. incubation. Survival curves plotted from the plate counts were always of different slope, being steeper for counts made on the 'Oxoid'. The ratios of the slopes varied from about two to more than six, depending on the type of radiation and the handling of the bacteria before irradiation (Figs. 1 and 2). After treatment by exposure to heat (51° C.) or to 0·6 per cent phenol, however, surviving fractions were the same on the two media.

Since fewer organisms formed colonies on 'Oxoid' than on 'Difco' agar, after a given dose of radiation, two possibilities were envisaged: first, that the 'Difco' medium might contain a higher concentration of growth factors for which the radiation had induced a special requirement, or secondly, that the 'Oxoid' medium contained factors which inhibited colony formation by the irradiated bacteria. The second alternative was found to be the correct one. Dialysable substances were found to be present in the 'Oxoid' nutrients which, when added to 'Difco' agar, caused the viable counts to be reduced to those observed on 'Oxoid' plates. One of these substances has been identified as chloride ion; the other, not yet identified, is associated with peptone which is present in higher concentration in the reconstituted 'Oxoid' medium. The evidence for these conclusions will be dealt with in detail elsewhere.

The results indicate that a particular type of radiation damage becomes apparent only when the bacteria are plated on a medium containing these dialysable substances, so that on other media the bacteria 'recover' from part of the total radiation effect. Our results resemble those of Roberts and Aldous[1], who plated *E. coli, B* after irradiation on synthetic and on nutrient agar, and found much the same relationship between viable counts on these two media, after ultra-violet irradiation, as we have found with 'Difco' and 'Oxoid' agar. They concluded that the nutrient medium contained a factor respon-

sible for bringing to light a part of the damage which did not appear when a synthetic medium was used. Roberts and Aldous, however, found no effect of medium on *E. coli*, *B* after X-irradiation.

The presence of oxygen increases the lethal effects of ionizing radiations on bacteria[2], but does not modify the effect of ultra-violet light (Alper, unpublished results). However, that part of the damage to *E. coli*, *B* which is medium-sensitive appears to be much less affected by the presence of oxygen than the part of the damage which is not medium-sensitive. Thus the medium effect on a washed suspension of stationary-stage *E. coli*, *B* was greatest with ultra-violet light, less with X-rays in anoxic conditions, and least with X-rays under oxygen. On the other hand, the enhancement by oxygen of the sensitivities to ionizing radiations (X-rays and neutrons) was considerably greater when the bacteria were plated on 'Difco' than when they were plated on 'Oxoid'.

Radiosensitivity (S) may be defined as the inverse of the dose (D) necessary to reduce the population of colony-forming bacteria to a given fraction of the controls. If it is correct to regard the medium-sensitive and the oxygen-sensitive parts of the damage as separable, then in the general case

$$S = m\Sigma\lambda m + \Sigma\lambda n$$

where λm represents components which in the presence of oxygen are increased by a factor m, while λn represents components not modifiable by oxygen. It will be assumed that with *E. coli*, *B* plated on 'Difco' agar the observed radiosensitivity itself contains components which are not modifiable by oxygen, so that

$$S_{Difco} = m\lambda_1 + \lambda_2$$

The extra sensitivity apparent from the action of the dialysable substances from 'Oxoid' medium will be denoted by λ_{ox}.

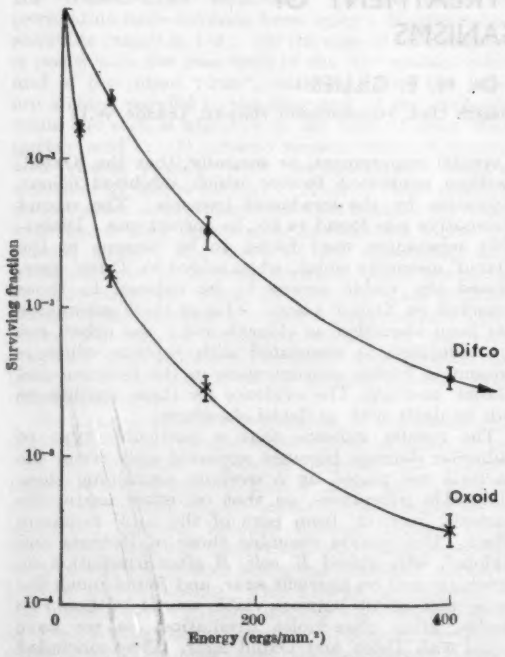

Fig. 1. Survival of *E. coli*, *B* in the stationary phase, after exposure to ultra-violet light

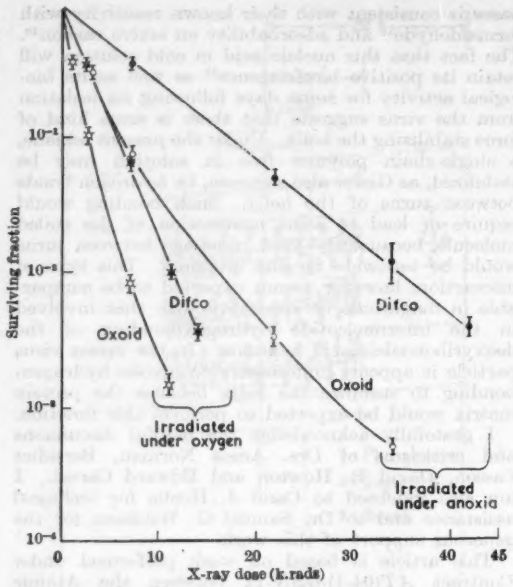

Fig. 2. Survival of *E. coli*, *B* in the stationary phase, after exposure to X-rays under oxygenation and anoxia

There are then four cases:

With anoxic irradiations
$$\begin{cases} S_{Difco} = \lambda_1 + \lambda_2 (\propto 1/D_1) \\ S_{Oxoid} = \lambda_1 + \lambda_2 + \lambda_{ox} (\propto 1/D_2) \end{cases}$$

Irradiations with oxygen present
$$\begin{cases} S_{Difco} = m\lambda_1 + \lambda_2 (\propto 1/D_3) \\ S_{Oxoid} = m\lambda_1 + \lambda_2 + \lambda_{ox} (\propto 1/D_4) \end{cases}$$

It would follow that

$$\frac{1}{D_1} + \frac{1}{D_4} = \frac{1}{D_2} + \frac{1}{D_3}$$

The doses found necessary to reduce the survivors of a suspension of *E. coli*, *B* to 10 per cent of the controls, with both X-rays and neutrons, are given in Table 1.

Table 1

Plating medium	Irradiated suspension	Symbol for dose to give 10 per cent survival	X-ray dose (k.rads)	Neutron dose (88 per cent neutrons, 12 per cent X-rays) (k.rads)
'Difco'	anoxic	D_1	16·8	8·8
'Oxoid'	,,	D_2	6·0	3·8
'Difco'	oxygenated	D_3	5·8	5·2
'Oxoid'	,,	D_4	2·9	2·6

For X-rays,

$$\frac{1}{D_1} + \frac{1}{D_4} = 0{\cdot}40$$

$$\frac{1}{D_2} + \frac{1}{D_3} = 0{\cdot}34$$

For neutrons,

$$\frac{1}{D_1} + \frac{1}{D_4} = 0{\cdot}49$$

$$\frac{1}{D_2} + \frac{1}{D_3} = 0{\cdot}47$$

For both types of radiation the agreement is within the limits of the errors involved in the determination of the doses required to give 10 per cent survival.

The relative radiosensitivities of test materials irradiated in the presence and in the absence of oxygen are of great theoretical importance. It is worth emphasizing, therefore, that the observed magnitude of this ratio for *E. coli, B* is dependent on the plating medium chosen. With 'Difco', the ratio of radiosensitivities to X-rays was observed to be $16{\cdot}8/5{\cdot}8 = 2{\cdot}9$ (given by $(m\lambda_1 + \lambda_2)/(\lambda_1 + \lambda_2)$, in the symbols defined above), whereas with 'Oxoid' as the plating medium the ratio was observed to be

$$\frac{6{\cdot}0}{2{\cdot}9} = 2{\cdot}1, \text{ given by } \left(\frac{m\lambda_1 + \lambda_2 + \lambda_{ox}}{\lambda_1 + \lambda_2 + \lambda_{ox}}\right)$$

It can be predicted that if a medium is used which will reduce λ_2 to less than its value with 'Difco', a still greater ratio of 'oxygenated' to 'anoxic' radiosensitivities will be observed.

The following bacteria have also been tested for survival after irradiation on 'Difco' and 'Oxoid' plates: *E. coli, B/R*; *E. coli, K12*; *E. coli*, 86; *Shigella flexneri, Y6R*; and *Salmonella typhimurium*. Only the last-mentioned showed an effect similar to that shown by *E. coli, B*, and this to a much smaller extent. However, post-irradiation modification of damage to various micro-organisms by different methods have been reported[3], and there are indications that effects may be found with other species which are analogous to those which occur with *E. coli, B*. It seems likely, therefore, that the extent of the oxygen effect observed with strains other than *E. coli, B* might be modified by the post-irradiation treatment. Such phenomena may be in part responsible for different oxygen enhancement ratios observed with closely related strains of micro-organisms[4], or for different ratios observed with the same strains in different laboratories.

We are greatly indebted to Mr. D. Moore for carrying out the neutron irradiations and dosimetry.

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INFRA-RED SPECTRA OF FREE RADICALS

By Dr. K. NOLEN TANNER* and RAYMOND L. KING
U.S. Naval Ordnance Laboratory, Corona, California

FLASH photolysis has been extensively used to produce momentarily a sufficiently high concentration of a number of free radicals to enable their absorption spectra to be observed in the photographic regions[1–4]. The availability of photoconductive detectors with time constants of the order of 10 μsec. or less makes it possible to examine fast reactions in the infra-red, and several rapid-scanning infra-red spectrometers have been designed and constructed for this purpose[5,6]. We have constructed such an instrument with a lead telluride detector and have used it to search for the N–H stretching frequencies of the NH_2 molecule.

The instrument is equipped with a calcium fluoride prism and uses a continuously rotating Littrow mirror. The mirror is aluminized on both sides and sweeps a spectrum across the exit slit twice in each rotation. An 'optical vernier' system supplies a set of fiduciary marks which enable the angular displacement of the mirror to be measured with a precision somewhat better than ½′. The spectrum and the markers are presented on the two traces of a DuMont Type 322*A* double-beam oscilloscope. The first marker in the set synchronizes the oscilloscope sweep and the high-intensity photolysis flash.

The flash is produced in the usual manner[3] in a quartz tube 1 m. long and 1 in. in diameter inside a cylindrical reflector adjacent to a quartz absorption cell 1 m. long and 2 in. in diameter. The spectrum source is a tungsten filament or Nernst glower forming an image on the entrance slit.

When hydrazine is photolysed at a pressure of about 1·2 cm. and with a flash energy less than 3,000 joules, the 3-μ doublet becomes rather ragged on the long wave-length side, but is otherwise unchanged. At flash energies of 3,000 joules and more, the explosive thermal decomposition of hydrazine is triggered[4]. The doublet disappears and is replaced by a broad region of absorption between slightly less than 3·00μ and about 3·24μ. The spectrum taken several seconds after the flash shows only the *Q*-branch of the NH_2 produced, with a shoulder on the long wave-length side due to undecomposed hydrazine.

Fig. 1 shows tracings of a typical sequence of records for a photolysis experiment. *A* is the comparison spectrum of hydrazine recorded several seconds before the flash is triggered; *B* is the flash record itself. The oscilloscope sweep, initiated simultaneously with the flash, was started at the point marked *X* and was carried off the face of the oscilloscope by the scattered light and the accompanying electric and electromagnetic noise pulse. Recovery was complete in 0·5–0·6 msec. *C* is the spectrum of ammonia and residual hydrazine, products of the reaction, taken several seconds after the flash. *D* is the set of fiduciary marks recorded with *C*. The markers recorded with the other traces have been omitted. *E* is a set of time markers recorded immediately after *C* by substituting in the spectrum channel the output from a 'Tektronix' Type 180 time-mark generator. The oscilloscope sweep has been expanded about three-fold and becomes somewhat non-linear at the edges, but this does not interfere with either the measurement of wave-length or time interval. The markers shown are at 0·1- and 1·0-msec intervals.

A number of such sets of records have been obtained, and, in general, the successive traces in a set can be reasonably well superimposed except in the regions

* Present address: Department of Ophthalmology, University of Oregon Medical School, Portland, Oregon.

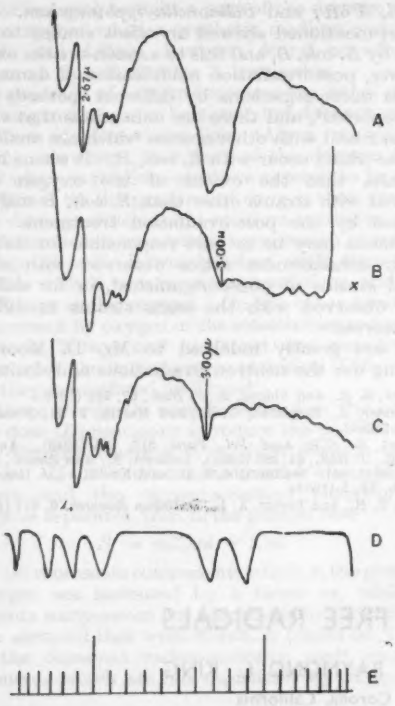

Fig. 1. Tracings of a typical record sequence. (*A*) Initial spectrum of parent compound (hydrazine). (*B*) Flash spectrum showing free-radical absorption. The spectrum is swept from right to left. (*C*) Product spectrum taken several seconds after the flash showing ammonia and residual hydrazine bands. (*D*) Fiduciary marks recorded simultaneously with *C*. (*E*) 1·0 and 0·1 msec. time marks recorded several seconds after *C*

of differing absorption and at the extreme ends. Using the final NH_2 spectrum as a background except in the 3-μ NH_2 band itself where the background was interpolated from the band edges, several records have been reduced to per cent transmission plots which are shown in Fig. 2. (In each case the abscissa is that of the original record and has not been reduced to a common linear wave-length scale; however, the measured wave-lengths are given.) It is noted that in every case a definite band appears at 3·125 ± 0·01μ. The 'fine structure' observed on one trace is probably a noise artefact. The time marks make it possible to determine the interval between the initiation of the flash and the appearance of the 3·125-μ band at the exit slit. These time intervals are given in Fig. 2. It is evident that the 3·125-μ band becomes progressively weaker and the 3·00-μ NH_3 band becomes stronger as the time between the flash and the passage of the band across the exit slit increases. It appears then that the absorption at 3·125μ is due to a transient molecule with a half-life somewhat less than 1 msec., but which can still be observed several milliseconds after the initiation of the flash. This corresponds with the kinetic behaviour of the α-bands ascribed by Herzberg and Ramsay to the NH_2 molecule[7,8].

There are two N–H stretching frequencies for this molecule in the 3-μ region, and if the force constants are not too different from those of NH_3, the symmetric stretching frequency, ν_1, will be at about 3·1μ and the unsymmetric frequency, ν_3, rather close to 3·0μ (ref. 7). It is impossible from the present records to distinguish unambiguously this latter band from that of NH_3. Nevertheless, it is evident that there is strong absorption between 3·0 and 3·1μ. Part of this absorption remains on the spectrum taken several seconds after the flash, and is evidently due to hydrazine. This might be expected as arising from the recombination of NH_2 radicals. However, the absorption intensity in this region is strong relative to the NH_2 band at 3·0μ immediately after the explosion, and the intensity decreases in much the same way as that of the 3·125-μ band. From an average of several estimates of the maximum absorption in this region immediately after the flash, the ν_2 band of NH_2 has been assigned the wave-length 3·049μ (3,280 cm.$^{-1}$). Using the assignments of ν_1 = 3,200 cm.$^{-1}$ (3·125μ), ν_3 = 3,280 cm.$^{-1}$ (3·049μ), and 103° as the valence angle[9], we have calculated the valence force constants[10] as k_l = 5·74 × 10^5 dynes per cm. and k_δ/l^2 = 0·31 × 10^5 dynes per cm. These values fall into the general pattern of force constants observed for other XY_2 molecules and for NH_2. The bending frequency ν_2 calculated from the simple valence force treatment has the value ν_2 = 1,060 cm.$^{-1}$ (9·4μ).

In addition to the NH_2 spectrum, Ramsay[8] observed NH bands. The absorption in the 3-μ region of the exploding gas is quite general, and absorption from NH molecules can certainly be accommodated in the observed spectrum. However, the band of the NH molecule at the high temperatures would be expected to be rather wide and relatively weak at the centre, whereas the two NH_2 bands, and particularly the ν_2 band, are expected to be more compact.

The possibility suggests itself that the absorption might be due to 'hot' molecules, either N_2H_4 or NH_3, and it is true that absorption from such species would be expected in this region. The rotational temperature observed by Ramsay[8] for NH radicals in the explosive decomposition of hydrazine is 1,400° K. Hydrazine decomposes thermally at a temperature of 250°–300° C. (ref. 11), and explodes at a much lower temperature when sparked. It seems unlikely that at 1,400° K. the molecule would last as long as a few microseconds, about 10^7 vibrational cycles, without decomposing. However, the principal argu-

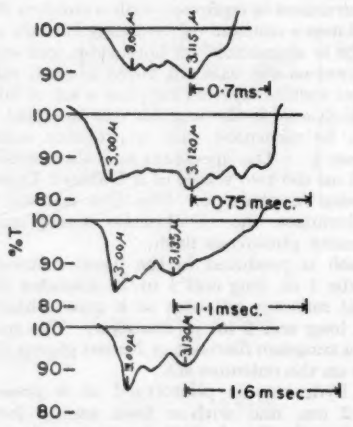

Fig. 2. Four flash spectra plotted as per cent transmission showing measured wave-lengths and delay times

ment against the assignment of these bands to either 'hot' N_2H_4 or NH_2 is the kinetic one. The maximum absorption of the transient band is about 0·75 msec. after the initiation of the flash, or about 0·6 msec. after the peak of the flash intensity. As the transient absorption decays, the 3-μ ammonia band grows at about the same rate. There is no period either before the appearance of the transient band or between it and the appearance of the NH_2 band which would accommodate an intermediate compound with a half-life anything like 1 msec. But Ramsay and Herzberg have convincingly demonstrated the presence of NH_2 radicals with a half-life of about 1 msec. in this system. The 'hot' molecule hypothesis then necessarily implies that: (1) the principal quantity of hydrazine is converted directly to ammonia without the formation of an intermediate compound with a half-life greater than a fraction of a millisecond other than the 'hot' molecule itself; and (2) that the NH_2 absorption coefficients are exceptionally small in the infra-red or exceptionally large in the violet. Neither of these implications is inherently plausible, nor is the first in accord with the postulated mechanisms of the reaction[11].

Ramsay and Herzberg[7] observed the NH_2 spectrum in the flash photolysis of 1 mm. of NH_3 ". . . with approximately the same intensity . . ."[8] as observed in the explosive decomposition of hydrazine. A considerable effort has been made to observe the 3·125-μ band in the photolysis of ammonia and in the non-explosive (using sub-critical flash energy) photolysis of hydrazine. The results have been uniformly negative. In the case of NH_3, this is not too surprising, since the decomposition of NH_2 requires light with a wave-length shorter than about 2100A., and a relatively small proportion of the flash energy will be in this region. Hydrazine photolyses on irradiation at somewhat longer wavelengths. Fig. 2 shows that the maximum optical density in the transient absorption is about 0·08. A reduction in partial pressure by a factor of ten would take the signal into the noise-level. When the α-bands are observed with photographic plates, however, the more or less linear relationship between the photographic density and the logarithm of the incident intensity would make the method much less sensitive to changes in optical density at very weak absorption-levels. In fact, if the plates were developed so that the zero absorption background still lay on the 'toe' of the characteristic curve, the increasing gamma for larger transmitted intensity (weaker absorption) would tend to suppress to the eye the effects of decreased radical concentration. Infra-red absorption coefficients are considerably smaller than those for electronic-vibration bands, so it appears to be evident that the flash alone simply does not supply enough effective photons to create an observable concentration of these radicals in the infra-red.

Norrish *et al.*[3,4] have photographed the ultra-violet spectra of a number of diatomic free radicals produced in explosions initiated homogeneously throughout the absorption cell by free radicals resulting from the flash photolysis of nitrogen dioxide or a similar sensitizing compound. Plots of the measured concentrations against the time from the initiation of the flash show a characteristic sharp rise in 0·1–0·6 msec., followed by a slower decay. Fig. 3 shows a similar situation for the present 3·125-μ absorption. The open rectangles give the measured absorption intensity relative to the original N_2H_4 intensity vs.

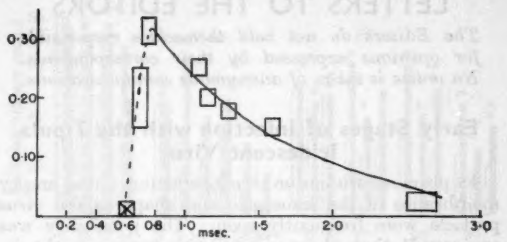

Fig. 3. Relative absorption intensity versus time after initiation of photolysis flash. Solid curve is logarithmic with a half-life of 0·7 msec.

the time in milliseconds after the initiation of the flash. The areas of the rectangles indicate the probable error limits of the measurements. The crossed square is the result of an experiment in which the 3·125-μ band was obscured by the flash, but no, or at most very little, absorption could be observed at 3·00μ 0·6 msec. after the flash. Electronic recovery was essentially complete at this wavelength at about 0·5 msec. Since little or no absorption was observed which could be ascribed to ammonia, the reaction product, or to the 3·05-μ (or vicinity) NH_2 band, it has been assumed that the absorption at 3·125μ is zero or almost zero. Another experiment, in which the 3·125-μ band was obscured by the flash but the 3-μ region was not, showed a small but definite absorption at 3·00μ at about 0·7 msec. The solid line curve is a logarithmic decay curve obtained by fitting by eye a straight line to the points on a semilog plot. The half-life is 0·7 msec. A record in which the 3·125-μ band was scanned at 4 msec. showed no detectable absorption. The NH_2 bands at 3μ were somewhat broadened, but otherwise the same as those scanned several seconds after the flash.

While not completely unambiguous, until high resolution can be applied to these bands, the best interpretation appears to be that they are principally due to NH_2 radicals with possible contributions from NH, N_2H_3, and 'hot' N_2H_4 and NH_3.

It has been shown that with the use of fast photoconductive detectors, infra-red spectroscopy can be applied to the study of free radicals and other short-lived molecules with conditions of resolution approaching those of conventional instruments using thermal detectors. Furthermore, by direct photometric techniques, kinetic studies can be made easily and relatively accurately.

Work on the spectra of other free radicals and a more complete description of the apparatus will be published elsewhere.

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LETTERS TO THE EDITORS

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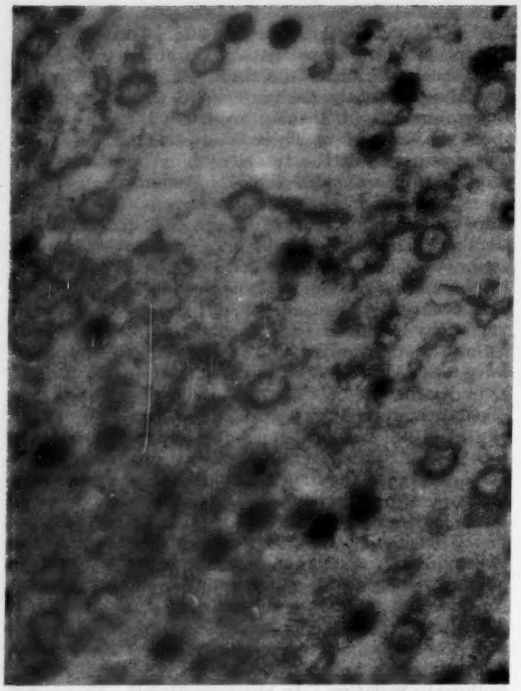
Early Stages of Infection with the *Tipula* Iridescent Virus

In previous studies on this interesting virus, empty membranes of the same size and shape as the virus particle were frequently seen. The possibility was envisaged[1] that these empty membranes might be incomplete virus particles analogous with the nucleic-acid-free 'top component' of the turnip yellow mosaic virus[2].

Further work, however, with ultra-thin sections of fat-body from infected larvæ of *Tipula paludosa* suggests an alternative explanation. Examination of material in the early stages of infection reveals the presence of these empty membranes in very large numbers; they are often more numerous than the normal virus particles (Fig. 1). Furthermore, they do not seem to occur in the advanced stages of the disease in which the virus particles are lining up to form microcrystals in the fat-body; in such a case all the virus particles are fully formed.

In addition to the completely empty membranes, others occur with a small dark central spot, varying in size in different membranes. It is, in fact, easy to pick out all the stages in which the size of the central spot varies, from the first beginnings to the completely filled membrane of the mature virus particle (Fig. 2).

It seems, therefore, a reasonable assumption that these empty and partly empty membranes may be stages in the development of the *Tipula* iridescent virus. This is further supported by the fact that they do not apparently occur in the late stages of the disease. Because these empty forms are the same size as the fully formed virus particle, the possibility is ruled out that the appearance is due to an oblique



[Fig. 2. Similar to Fig. 1, but showing several membranes with a developing centre. (× 40,000)

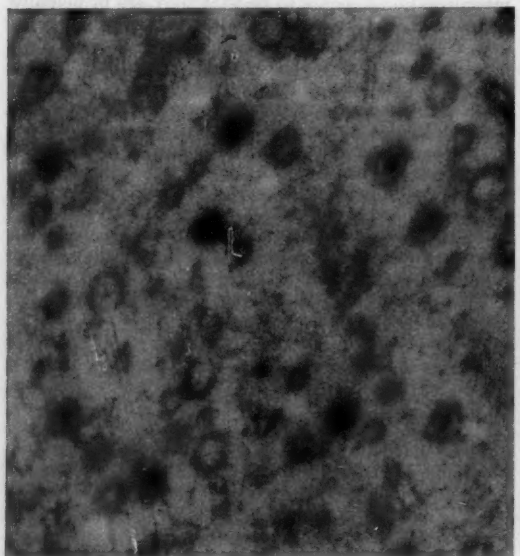


Fig. 1. Ultra-thin section of *Tipula* fat-body showing numerous empty membranes; virus particles appear dark. (× 40,000)

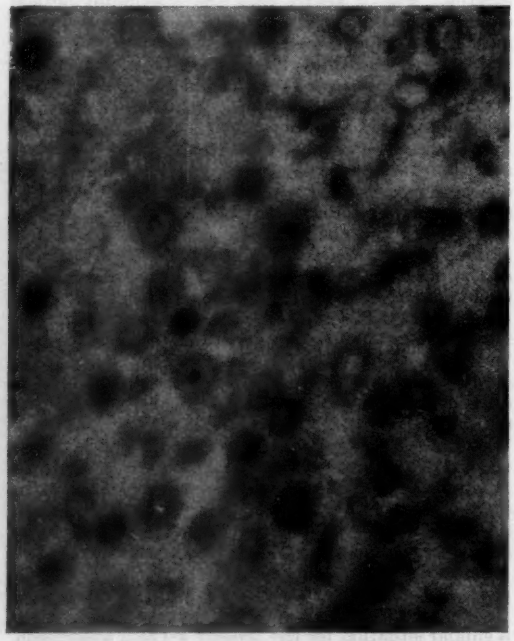


Fig. 3. Similar to Fig. 1, but showing the resemblance between the virus membranes and the endoplasmic reticulum. (× 40,000)

section passing through part of the particle only. On this assumption, the process seems to be that the membrane forms in the cytoplasm first, and then the deoxyribonucleic acid and protein begin to appear as a small darkly staining spot in the centre gradually increasing in size until the membrane is filled.

Another rather striking fact, which may of course be coincidental, must be pointed out. This is the truly remarkable resemblance between the empty virus membrane and the endoplasmic reticulum[3]. The diameter and appearance of the limiting membranes appear identical and here again all grades exist between the long forms and the oval-shaped membranes of the endoplasmic reticulum; these latter cannot be differentiated on the electron microscope from the empty virus membranes (Fig. 3).

I am indebted to Mr. G. J. Hills for taking the electron micrographs.

KENNETH M. SMITH

Agricultural Research Council,
Virus Research Unit,
Cambridge.

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Influence of Cocarboxylase on Tolerance to Morphine in the Rat

THE basic physiological mechanism affected by morphine may be that of the enzymatic processes involved in glucose metabolism: it is known, indeed, that morphine inhibits glucose and pyruvic acid utilization by minced brain[1], and the decarboxylation by rabbit's liver and brain homogenates of pyruvic acid[2]. Further, morphine is known to reduce the level of carbon-14 in brains of rats fed with labelled glucose[3]. Cocarboxylase activity is unaffected in chronically morphinized rats, but responses to pyruvate and cocarboxylase of *in vitro* muscle from animals deficient in thiamine and from chronically morphinized ones are similar, suggesting a metabolic defect in common to both conditions[4]; thiamine has no effect on morphine withdrawal symptoms in man[5], though it decreases their intensity in rats[6]. Lastly, glycids and their metabolites change the analgesic effect of morphine.

We therefore investigated the influence of thiamine and of cocarboxylase on the analgesic effect of morphine and on the appearance of tolerance to this effect.

Ninety rats were used in three sets of experiments. The animals, after a control analgesimetric test for a standard dose of morphine, were treated daily with thiamine or cocarboxylase followed 30 min. later by morphine. Controls received daily morphine only. In the course of treatment analgesimetric tests were carried out about every ten days. The analgesic effect of morphine was determined by the D'Amour and Smith technique and the analgesic efficacy was estimated in minutes and seconds of analgesia[7]. Table 1 shows the scheme of treatment in each set of experiments, and Fig. 1 shows the results.

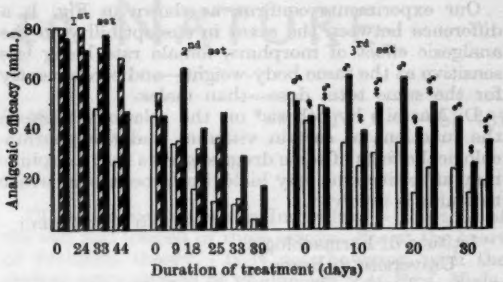

Fig. 1. Analgesic efficacy of a standard dose of morphine in successive tests in control animals and in animals pretreated with thiamine or cocarboxylase during chronic treatment with morphine. Open columns, controls; diagonally shaded columns, pretreated with thiamine; black columns, pretreated with cocarboxylase

In our experimental conditions, daily treatment with thiamine or cocarboxylase at first prevented and afterwards delayed—in comparison with the controls—the progressive appearance of tolerance to the analgesic effect of morphine. In these conditions we were not able to detect any analgesic effect due to thiamine or cocarboxylase, or any potentiating effect, in a merely pharmacological sense, of the analgesic effect of morphine. The main observations were as follow:

(*a*) With the progressive appearance of tolerance to the analgesic effect of morphine, the behaviour of the control animals changes; they become hyper-excitable, hyper-reactive and aggressive. This does not happen with the animals pre-treated daily with thiamine or cocarboxylase until the analgesic response remains unchanged or moderately decreased. Tolerance and change in behaviour may, therefore, be connected.

(*b*) The abrupt interruption of the daily morphine treatment in the controls—once tolerance to the analgesic effect has appeared—induces on the following day a moderate state of depression. This does not happen with animals pre-treated with thiamine or cocarboxylase.

(*c*) Instituting treatment with cocarboxylase in controls which have become tolerant to the analgesic effect seemed to accelerate the rate of recovery of the analgesic response to morphine.

Table 1. SCHEME OF TREATMENT

		No.	Weight (gm.)	Sex	Test morphine (mgm./kgm. subcutaneous)	Treatment (10 mgm./kgm. intraperitoneally)	Morphine		Time (days)
							Route	mgm./kgm./day	
1	Controls	10	130–200	♂ and ♀ (random)	10	Sodium chloride 9°/₀₀	Subcutaneously	10th until the 25th day	42
	Pretreated	10				Thiamine		15th until the 34th day	
	Pretreated	10				Thiamine + cocarboxylase		25th until the 42nd day	
2	Controls	10	120–160	♂ and ♀ (random)	5	Sodium choride 9°/₀₀	Subcutaneously	15	40
	Pretreated	10				Thiamine			
	Pretreated	10				Cocarboxylase			
	Controls	20	90–100	♂ and ♀ 1:1	7·5	Sodium chloride 9°/₀₀	Intraperitoneally	15	30
	Pretreated	10				Cocarboxylase			

Our experiments confirm, as shown in Fig. 1, a difference between the sexes in susceptibility to the analgesic effect of morphine, female rats being less sensitive at the same body-weight—and consequently for the same total dose—than males.

Di Mattei's hypothesis[9] on the relations between the functions of certain vitamins and the pharmacological effects of some drugs suggests that morphine may affect in some way biological processes in which thiamine is involved.

Luciano Angelucci

Istituto di Farmacologia,
Università di Roma.

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Effect of Hypothermia on Death by Starvation

It is known that during the winter months some animals adjust themselves to unfavourable living conditions, particularly food shortage, by hibernation. This leads to a considerable lowering of the total metabolism and a drop in body temperature which enable the animals to survive the winter with a minimum consumption of nutrient.

Recently some very interesting substances have been prepared, for example, chlorpromazine, which produce an effect in some respects resembling hibernation. Hence the term 'artificial hibernation'. Chlorpromazine has been used with good results in psychiatry, surgery, pædiatrics and clinical states with a general hyper-reactivity of the patients.

We attempted to solve the problem, whether the effect of this substance can in some manner protect the animal from death from starvation, as this is, no doubt, the main purpose of hibernation in Nature.

The experiments were carried out on rats. We used 10 rats which had been fed on a standard diet (Larsen). They were then deprived of food while they had free access to water. Half the animals received chlorpromazine (Largactil Specia), 5 mgm./kgm. body-weight daily. The second group was used as control. Chlorpromazine, which lowered the body temperature of the experimental group by 3° C., caused a general apathy with a lowering of voluntary movements, but did not exert any influence on the time of survival (control group $6{\cdot}0 \pm 1{\cdot}4$, experimental group $6{\cdot}5 \pm 1{\cdot}73$ days; $P = 0{\cdot}7$) or on the loss of weight. The weight curves were the same in both groups. Nor was the excretion of nitrogenous substances much affected (control group 120 ± 27, experimental group 100 ± 12 mgm. nitrogen/24 hr./100 gm. weight; $P = 0{\cdot}2$) and ketone bodies (expressed as acetone) in the urine (control group $0{\cdot}18 \pm 0{\cdot}05$, experimental group $0{\cdot}19 \pm 0{\cdot}07$ mgm. ketone bodies/24 hr./100 gm. weight; $P = 0{\cdot}8$).

Apparently the drop of body-temperature under the influence of chlorpromazine was too small to protect the animals from death by starvation. We did not want to use larger doses of chlorpromazine for fear of pharmacological side-effects. Therefore in subsequent experiments we chose young rats (10 days old) because, as is well known from the literature[1–4], their body-temperature can easily be lowered to the environmental temperature. We used suckling rats from the same litter of which half (5 animals) were kept at an optimal temperature of 30° C., the second group at 20° C. Both groups of animals were taken from their mothers at the same time. The body-temperature of the animals kept at 20° C. dropped considerably within 15 min. and the rate of respiration decreased by as much as 40 per cent. In spite of this the group which survived in the colder environment was not protected against death by starvation. The time of survival at a temperature of 30° C. was $98 \pm 13{\cdot}6$ hr., at 20° C. $85 \pm 9{\cdot}9$ hr. ($P = 0{\cdot}2$). The total weight-loss as compared with the control group was, however, less than half (12·5 per cent loss of body-weight in animals kept at 20° C.; 34·3 per cent in animals kept at 30° C.; $P < 0{\cdot}01$). It is interesting that the relative composition of the carcase was, in both groups, practically the same. The animals kept at 30° C. had at the end of the starvation period a carcase composition of 80 per cent water, 20 per cent dry matter, 2·4 per cent nitrogen; the animals kept at 20° C. 82 per cent water, 18 per cent dry matter, 2·1 per cent nitrogen. During starvation, however, the control group kept at 30° C. lost 2·1 gm. more water (that is, 175 per cent more).

The animals kept at a temperature of 20° C. were pale, apathetic, with voluntary movements reduced, and a slow rate of respiration. The opposite was true of animals starving at 30° C.; they also had very strong sucking reflexes. It is interesting that as compared with the first group we noted a marked growth of fur in these animals during the starvation period.

The most probable explanation of our findings is that the hypothermia caused by chlorpromazine bears no relation to the reduction of the total energy metabolism. This is in agreement with the work of Ankermann and Jung[6], who showed that oxygen consumption in such animals is not reduced but actually has a tendency to rise. Chlorpromazine could cause a lowering of oxygen consumption and a reduction in metabolic rate if at the same time the body was cooled physically, thus lowering the temperature twice as much as in our experiments.

However, even experiments on young rats, where the reduction of body-temperature was as much as 10° C., did not protect the animals from death by starvation. This fact (independently confirmed at another laboratory: Faltová, E., and Konečná, V., personal communication) is very interesting from the point of view of the mechanism of death by starvation, since hypothermia protects animals, particularly young animals, from short-term stresses, such as anoxia, pain and poisons.

From our experiments, and those of other workers using 'artificial hibernation', it appears that the term 'hibernation' is not suitable.

T. Braun
B. Mosinger

Physiological Department,
Institute of Human Nutrition,
Budějovická 800, Prague 14.

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THE INDIVIDUAL: UNIQUE BUT IMPERFECT

The Uniqueness of the Individual

By Professor P. B. Medawar. Pp. 191. (London: Methuen and Co., Ltd., 1957.) 18*s*. net.

ARTICLES and lectures published by Prof. Medawar over the past twelve years are here collected together and presided over by an essay on the wider implications of skin grafting specially written for the volume. That Prof. Medawar should exhibit an easy command over his material is to be expected; his equal command over the English language will give great pleasure to his readers, whose close attention he constantly rewards by a turn of phrase or a felicity of expression which enlightens as it entertains.

The eight essays range widely, but Prof. Medawar threads them together upon the topical theme of evolution. To this end he devotes his introduction to a defence of natural selection, which prepares the way for the first two essays. These start by formulating the evasive phenomena collectively recognized as 'growing old'; and then develop Medawar's idea that ageing is a consequence of the declining impact of natural selection upon those members of a population who have lived longest and who, owing to the mere hazards of time, contribute least to succeeding generations. That adaptation may proceed faster during the earlier phases of an animal's life-history than later on has important consequences for the comparative zoologist as well as for the actuary.

It is perhaps particularly in "A Commentary on Lamarckism" that Prof. Medawar's interest and skill in the careful definition of terms and the orderly unfolding of an argument are made apparent. Lamarckism takes a 'weak' and a 'strong' form: the weak form asserts that some types of inheritance could be interpreted in a Lamarckian fashion; the strong form asserts that these are correctly so interpreted—an assertion which Medawar finds unproved among the Metazoa and meaningless among the microbes.

Helmholtz's somewhat insensitive strictures upon the human eye were provoked by the perfectionist school of evolution, which may not be vocal to-day. But adaptation is still too often regarded as a condition rather than as a process, an arrival rather than an optimistic journey, and it is against this error that the essay on "The Imperfections of Man" is directed. As a newly evolved organism, man may perhaps be unusually imperfect, but this is hard to assess since he has kicked over the scales, shaping rather than being shaped by the environment, doctoring his ailments and supplementing genetic inheritance by tradition. This is the subject of a short essay on "Tradition: The Evidence of Biology", in which the reader is spared the too obvious and humiliating undertones of a theme which earlier generations of Darwinists would have developed with robust confidence.

"The Uniqueness of the Individual"—the title of the last and longest of these essays—lies at the heart of evolution theory. It is not, however, with the evolutionary aspects of uniqueness that Prof. Medawar is here primarily concerned, but with a new manifestation of uniqueness and the light which this throws on the organization of the individual. The preliminary facts are provided by modern surgery: skin can be transplanted from one part of an individual to another, but not from one individual to another. But there are significant exceptions to this rule: transference is possible between identical twins, members of very pure strains, embryos, or individuals whose blood-streams have been naturally or artificially confluent during embryonic life. Prof. Medawar gives an account of the reasoning and the series of critical experiments by which he and his colleagues, among others, have explored these phenomena.

There are two questions. First, what is the unique substance or group of substances apparently produced by all the tissues of an individual? Secondly when a tissue is transplanted into another member of the same species, what is the mechanism activated by this substance causing the host to treat the graft as a foreign body and destroy it? To these two questions it is to be expected that Prof. Medawar, as a zoologist, should add and discuss the answer to a third: What are the normal functions of these processes which have been almost accidentally brought to light through surgical practice and experiment? He suggests, only to reject, the idea that the tissue exudate is a sort of queen-substance which regulates the growth of the body. But is not the alternative suggestion—that, having passed from the nucleus to perform its function in the cytoplasm, it emerges from the cell as a mere excretion—too great an anti-climax? Excretion is a favourite disguise for elusive physiological processes. Many of these investigations have been reported in specialized medical journals, but they are of great consequence for biology in its widest sense, and biologists of many sorts will be most indebted to Prof. Medawar for publishing this masterly survey of a challenging field of research.

D. A. PARRY

THE FACE-CULT

The Eye Goddess

By Dr. O. G. S. Crawford. Pp. 168+48 plates. (London: Phoenix House, Ltd., 1957.) 50*s*. net.

THOSE acquainted with the services which Dr. O. G. S. Crawford rendered to prehistoric archæology will read this interesting, speculative book with mingled feelings of gratitude and regret, since its publication was followed immediately by the author's lamented death (*Nature*, January 18, p. 156). If his chief contribution to the science has

been in the domain of air photography and as the founder and editor of *Antiquity*, in this volume (written, incidentally, in the first instance for readers of *Antiquity*) he has shown remarkable powers of detection in the elucidation of obscure symbols on rock-carvings, cult-objects, megalithic monuments and other tombs and temples. These enigmatic figures have long been a matter of discussion and speculation, and in recent years it has become increasingly clear that they were very intimately connected with the cult of the goddess in its various forms and phases.

The axes and daggers which Mr. R. J. C. Atkinson found carved on the sarsens of Stonehenge in 1953 started Dr. Crawford on his quest and eventually led him to a temple at Brak in the Khabur valley in eastern Syria, belonging to the Jemdet Nasr period about 3000 B.C. In this sanctuary, dedicated to the Mesopotamian goddess Inanna-Ishtar, Prof. Mallowan discovered in 1937–38 a quantity of female figurines with very prominent eyes, sometimes associated with similar male figures, representing in all probability cult-images of the mother-goddess and her consort son. Statuettes of this nature, so prevalent from the eastern Mediterranean and the Fertile Crescent to the Indus valley, suggest the wide-spread distribution of a fertility ritual in the ancient Near East connected with the renewal of vegetation at the annual festival in the spring.

On this hypothesis, for which there is reasonably strong presumptive evidence, Dr. Crawford proceeds to trace the diffusion of the "Face-cult" westwards in successive waves overland through, or (as he thinks more likely) by sea around, Anatolia to the Troad, the Aegean, Crete and Greece, and thence to the Danube basin; along the Mediterranean to southern Italy, Sicily, Malta and Spain, with possible extensions to north Africa and the Canary Islands. Northwards, following the Atlantic littoral, it made its way along the coastal megalithic route to Brittany, Ireland, Britain and north-west Europe. Thus, at Los Millares in Almeria, where contacts with the Aegean, Crete, Anatolia and the eastern Mediterranean have been recognized for some time, 'owl-eyes' were painted on cist plaques, bovine phalanges, and stone and ivory cylinders found in megalithic tombs. In the northward extension of the cult the links become increasingly less apparent and problematical; nevertheless, Dr. Crawford has been able to make a fairly convincing case for an unbroken chain connecting its probable appearance in Brittany and Ireland in the second millennium B.C. with that in Anatolia, and ultimately, in the previous millennium, at Brak in Syria. Its arrival in northern Britain, very likely from Ireland with the passage graves, raises a number of problems regarding dating and technique that await final solution. This also applies to the Danish 'owl-faced pots' and their possible connexions with similar sherds from Los Millares, and the other indications of Danish–Iberian relations.

If there are some weak and missing links in the evidence at present available, this provocative volume, with its excellent photographs, drawings and maps, focuses attention on a complex of widely dispersed cult-symbols which hitherto have not received the serious consideration their importance and significance merit. It is indeed regrettable that the author could not complete the inquiry he had begun with such ingenuity and promising results.

E. O. James

DARWIN AND THE HISTORY OF SCIENCE

The Darwin Reader

Edited by Prof. Marston Bates and Dr. Philip S. Humphrey. Pp. ix+481. (London: Macmillan and Co., Ltd., 1957.) 30*s*. net.

We are here given a reprint of Darwin's "Autobiography" and extracts from several of his books. Some of the extracts are long—more than a third of "The Origin of Species" is included, and about one-sixth of "The Descent of Man". There are also shorter extracts from "The Expression of the Emotions", "Climbing Plants", "Insectivorous Plants" and "The Formation of Vegetable Mould by Earthworms". It is a pity that these last extracts could not have been longer, for Darwin's minor works are some of the most fascinating books in zoological literature, giving as they do a very clear insight into his methods of work as an investigator.

In their introduction the editors state that their object was to provide a book for a course aimed at giving students who will not be scientists, and who will presumably not have much general knowledge of biology, some appreciation of scientific thought. When they read Irvine's biographies of Darwin and Huxley in "Apes, Angels and Victorians", it seemed to them that there was a book that could be used "to build up an illuminating case-history in the development of science", but that if students were to read about Darwin they should also read some of his works. They could scarcely be asked to give the time needed for reading the whole books.

The compilation has been well done, and the book gives a sound view of Darwin's broad outlook as a naturalist and the fairness of his argumentation. But it is less clear that the book is suited to the object for which it was designed. In reading Darwin's work, anyone acquainted with modern biology continually meets passages which would certainly be written differently to-day. At several points Darwin's views have definitely been discarded, as, for example, his belief that the species is nothing more than a stage in the process of differentiation, his attribution of sexual selection to æsthetic appreciation by the opposite sex, and, for most modern biologists, his frequent recourse to Lamarckian inheritance as a real, if not a primary, cause of evolution. It is to be expected that not all his beliefs should be accepted after a lapse of a century, and it is the best test of the soundness of his work that it has stood the test of time with so little modification. But if a student who has not a good background of modern biology reads Darwin, and him alone, he will certainly get an out-of-date view of evolution and its theory.

The book might well be useful in a course on the history of science at a later stage of biological education, though in such a course the books themselves should perhaps be read; no one better than Darwin can easily be found as an exemplar of scientific argument. For the purpose for which the book was designed it would seem that some more recent work would be more appropriate. It is true that a few recent books on evolution are cited in an appendix as suggestions for further reading, but it seems that the student should know the modern theory *before* he takes up the reading of Darwin.

Whatever doubts one may have concerning the use to which the book is to be put, any work that may encourage biologists to take an interest in evolution and the history of its theory is welcome, and this book should certainly do that. It is especially valuable that the "Autobiography" should be reprinted; this has not been done, to my knowledge, since Darwin's "Life and Letters" were published by his son in 1887.

G. S. CARTER

THE MECHANISM OF INSECT FLIGHT

Insect Flight

By Dr. J. W. S. Pringle. (Cambridge Monographs in Experimental Biology, No. 9.) Pp. viii+133. (Cambridge: At the University Press, 1957.) 15*s*. net.

THE problem of how insects fly has interested biologists for a very long time. This interest has been intensively revived, partly as the result of the development of new techniques, since the War. Half the references on which "Insect Flight" is based are from the past ten years, showing new productivity which would be sufficient reason in itself for a monograph. But the immediate reasons for its appearance are twofold. One is the realization (by Boettiger and Pringle, independently) that in insect flight muscle, particularly that of the higher orders of insects, there are peculiar physiological mechanisms of considerable interest. The interpretation of these may throw new light on problems of the functioning of muscle tissue in general. The other is the recent publication of several papers which describe a very thorough investigation of the flight of locusts made by T. Weis-Fogh, a brilliant pupil of the late August Krogh. This work made the minimum of assumptions, utilized exact methods and rigorous analysis and thereby greatly illuminated the whole problem. These matters are dealt with in the monograph. At every stage in the presentation new lines of development are made apparent. In particular, the elucidation of the special physiological problems of the flight muscles offers a rewarding challenge, and the aerodynamic problems which have been overcome by extremely small flying insects require clarification.

The monograph illustrates well the newer approach to problems of experimental biology, in which the artificial barriers between collateral disciplines are broken down in the interest of solving a single functional problem. The anatomy, fine-structure, cytology, biochemistry, sensory and motor physiology and flight dynamics of the relevant parts are all given careful treatment. Critics of this approach will have to look hard for traces of superficiality. It is noteworthy in this connexion that most of the recent advances reported have come from zoologists who, like Weis-Fogh, have mastered other disciplines with no other end in view than bringing their techniques and principles to bear on the insect problem. Insect flight has in the past attracted a lot of attention of the arm-chair variety, with the result that it suffers from a number of unwarranted simplifications. Now it has advanced far beyond the string-and-sealing-wax stage and is being placed on a firm foundation of observation and theory.

The text is extremely well illustrated with 52 text-figures including several original drawings. All pay tribute to Dr. Pringle's superb draughtsmanship and unique sense of emphasis. The book suffers from only one fault—that of being difficult to read; but this only reflects the complexity of the mechanisms of insect flight and the inevitable consequences of the distillation of information.

It is a pity that the important work of Rodendorf (1951) on dipteran flight was not covered. Also the observations of Larssen on the thoracic muscles of gyrinid beetles, some of which fly although completely lacking dorsal longitudinal muscles. Pringle notes that the dorsal longitudinal muscles of some beetles are reduced in size. Their function is taken over by the basalar and subalar muscles. (I am indebted to Mr. R. A. Crowson for directing my attention to these papers.)

"Insect Flight" is a book in which many physiologists, biochemists and biophysicists as well as zoologists should find much to interest them. It has the advantage shared with other books in the series of being at a price which one can afford and of a length which permits reading from cover to cover.

GRAHAM HOYLE

FISH PHYSIOLOGY

The Physiology of Fishes

Edited by Margaret E. Brown. Vol. 1: Metabolism. Pp. xiii+447. 12 dollars. Vol. 2: Behavior. Pp. xi+526. 14 dollars. (New York: Academic Press, Inc., 1957.)

The Physiology of the Pituitary Gland of Fishes

By Grace E. Pickford and James W. Atz. Pp. xxiii+613. (New York: New York Zoological Society, 1957.) 6 dollars.

DR. MARGARET BROWN does not tell us how she came to have the idea of asking a number of authors to write upon different aspects of the physiology of fishes. It was a very good idea, and the result has been two volumes that will be of value and delight to many general zoologists as well as to those interested especially in fishes and fisheries research, to whom she says they are specially directed. Although there are no close links between the various sections, there is evidence that Dr. Brown has unobtrusively played a considerable part in editing the whole. In particular, she has herself set for each author the extent of his contribution—an excellent plan, which has ensured special emphasis on fields often neglected or of special interest because of recent work. Dr. Brown's own article on "Experimental Studies on Growth" is a good example. She has succeeded in collecting many fascinating facts about the determination of the age and growth of fishes and relating these to general biological problems.

Inevitably, any book that deals with the physiology of an arbitrarily chosen group of vertebrates will seem in some respects disjointed. One regrets particularly that neither amphioxus nor ascidians have been considered to be 'fishes'. Without them the discussions of the evolution of, for example, digestion and the endocrines inevitably lose some of their interest—though both remain fascinating enough.

The depth of the treatment and extent of literature quoted vary somewhat. There are more than 125 references on the swim bladder, but only eight on colour changes. Generally speaking, the work will

serve to give an introduction to the special features of the physiology of the various organ systems of fishes, and in some cases, but not all, will provide a critical discussion of the current problems.

The monograph by Drs. Pickford and Atz on the pituitary of fishes goes much deeper. Every aspect of the subject is treated in the greatest detail, and the result would be fascinating were it not for the severe difficulty of reading imposed by the hideous type, with lines much too long and unaligned. The effect of this extensive review is to emphasize that a very large body of detailed fact is available and yet is little used by biologists. Co-ordination of ideas only becomes possible when a full and scholarly treatment such as the present one becomes available.

An interesting feature is the discussion of the use of injection of pituitary extracts in pisciculture in Brazil and the U.S.S.R. The authors have gone to great trouble to obtain translations from the original papers published in those countries. They are able to present a full survey of the techniques, and the results claimed for them. It is especially interesting to have an account of the sequence of enthusiasm for the method by the schools of Skadovskii and Gerbils'kii and the criticisms by Derzhavin. The work has involved very thorough study of the breeding habits of the various races of sturgeon and other fishes and comparison of the results of natural and artificial spawning methods. That the former should be the more efficient is not surprising, but the latter is becoming increasingly necessary as the sturgeons are cut off from their up-stream spawning grounds by dams.

The book is dedicated to Prof. Petrunkevitch on his eightieth birthday, and he has himself performed much of the translation from the Russian.

These two works together emphasize that comparative physiology is growing up into an extensive discipline contributing greatly both to theoretical and practical biology. J. Z. Young

HISTOLOGY

A Student's Histology

By H. S. D. Garven. Pp. xii+650. (Edinburgh and London: E. and S. Livingstone, Ltd., 1957.) 55s. net.

Of the various text-books of histology of the traditional type, designed to meet the needs of the medical student, this is one of the best I have seen. It is an excellent work which despite minor blemishes deserves great praise. Dr. Garven has succeeded admirably in steering a course between what he terms "the Scylla of elaborate detail . . . and the Charybdis of over-simplification". The essential facts are presented clearly and concisely yet the student is always encouraged to keep an open mind and be prepared, when necessary, to consider more than one point of view. The diagrams are in general simple but effective, clearly emphasizing the points to which attention is being directed—for example, the scheme of the splenic circulation on p. 251, or the figure of the renal corpuscle on p. 438. The only doubts which assail one in reviewing such a book concern the extent to which the teaching of histology should incorporate some of the revolutionary changes which are now taking place.

It was in 1850 that Kölliker produced one of the earliest classical texts in histology, and it is interesting to note that this pioneer in his subject, who was professor of anatomy and physiology at Würzburg, gave his book the title of "Mikroskopische Anatomie". The great anatomist Jacob Henle had already, in 1841, extended the scope of anatomy from macroscopic down to molecular detail. In the introduction to a shorter "Handbuch der Gewebelehre", published in 1852, Kölliker wrote: "If it be possible that the molecules which constitute cell-membranes, muscular fibrils, axile fibres of nerves, and so forth, should be discovered, and the laws of their apposition, and of the alterations which they undergo in the course of the origin, the growth, and the activity of the present so-called elementary parts, should be made out, then a new era will commence for histology. . . ."

In the light of the vast body of new facts which in our own day are so rapidly accumulating through the use of the electron microscope and other agencies, Kölliker's prophecy of 105 years ago is well on the way to fulfilment. The new era in histology which he foretold has indeed commenced. From now on text-books of histology must incorporate to an increasing extent the newer concepts, which will bring histology ever closer to the molecular level, and demonstrate with yet greater precision the integration of structure and function, as the newly explored territory of the cell is mapped out afresh. J. M. Yoffey

NORTH AND CENTRAL EUROPEAN FLORA

Flora von Nord- und Mitteleuropa

Von Friedrich Hermann. Pp. xii+1154. (Stuttgart: Gustav Fischer Verlag, 1956.) 98 D.M.

This is a remarkable book. It is the work of an amateur botanist living in a small town about 85 miles south-west of Berlin and therefore without ready access to the vast amount of literature concerning European plants which has accumulated during the past two centuries. Nevertheless, it contains a great deal of information, both descriptive and distributional, in a single volume of convenient size but unreasonable price. The brief preface gives all too little information about the area covered, the sources used (there is no bibliography), and the general plan and purpose of the book. One is left longing to know more, particularly of the author's obviously extensive journeys and of his views on species and subspecies.

So far as can be discovered from the preface and from the species included in and excluded from the body of the work, the area covered may be outlined roughly as follows: Iceland, Spitsbergen, Fennoscandia, Poland, Carpathians, Bulgaria, Alps (south to the Alpes Maritimes), the line of the Rhône and Seine and the British Isles. The author has, he says, no personal knowledge of the western Alps, the British Isles, Iceland and Spitsbergen, but appears otherwise to have sampled the area with such thoroughness that he claims to have seen the majority of the species growing wild and to have cultivated many of them in his garden.

The descriptive part of the flora occupies rather more than 1,000 pages and deals with approximately 4,500 species, which is a little more than a quarter of the estimated total number of species in Europe. The exclusion of the Iberian peninsula, most of the Balkan peninsula, a considerable part of east Europe and of

all the Mediterranean plants, except for the few which ascend sheltered valleys in the southern Alps, accounts for the remaining three-quarters of the European flora.

The well-known Engler and Prantl system of classification is followed, perhaps a slight disadvantage to some British users of the book. The descriptive information is contained in extended keys which are clearly set out and easy to use, though in places rather fuller descriptions would have been helpful. These keys often contain information derived from personal observations, which greatly enhance the value of the work. Flower colours are described in general terms and then often made more precise by reference to Ostwald's colour scale: a useful innovation.

Not infrequently two or more taxa are keyed out together and then indicated in such a way as to leave one in complete doubt about whether the author regards them as species or subspecies or even varieties. For example, in the key to *Cytisus* (p. 592) he has:

"4. . . . Hülse ganz kahl (*leiocarpus* Kerner 1863) bis angedrücht seidenhaarig. . . . *ratisbonensis* Schäffer 1760.

4* . . . a) Krone weiss bis blassgelb, Kelch zottig, bis 12 mm. lang. *albus* Hacquet 1790. a* Krone sattgelb. *austriacus* L. 1763. . . . *austriacus* L. 1763.

One might guess from this that *leiocarpus* is to be regarded as a variety of *C. ratisbonensis* and that *C. austriacus* has two subspecies, but when one looks at the distributions one finds all three taxa are given binomials, as though they were species.

Other, though less important, peculiarities are the fairly abundant invention of new sectional names (indicated by asterisks), without a word of definition, and certain liberties with nomenclature. Herr Hermann believes in consistency more than in the international code. He says, "Ich schreibe daher stets chloa nicht bald chloa, bald chloë", etc., and prefers *Heleocharis* to *Eleocharis*.

T. G. Tutin

CHROMOSOME SCIENCE

Cytology and Genetics

By Prof. Carl P. Swanson. Pp. x+596. (Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1957.) 13.35 dollars.

THIS is an ambitious book. It sets out to cover every aspect of nuclear cytology, the function and structure of the chromosomes, their movements and their crossing-over, their variation and their evolution, their chemistry and their organization into genes; and, very properly, it seeks throughout to integrate the information from cytological examination with the results of the breeding experiment. Twenty-five years ago this was already a big task to essay. To-day it is tremendous and the author is to be congratulated not only on his courage in tackling it, but also on the success he has achieved. In surveying, and be it noted surveying at the research level, so large a field, Dr. Swanson inevitably finds himself dealing with much that is away from his own direct interests. Equally inevitably, this is reflected in the quality of the treatment. There is a confidence, for example, in the handling of induced aberrations of the chromosomes, which is lacking from the treatment of nuclear behaviour in differentiation. Again, a topic is sometimes taken up more than once in different parts of the book, with conclusions that are not always fully co-ordinated; but this is scarcely to be avoided in so extensive a survey.

It is a measure of the book's achievement that "Cytology and Cytogenetics" invites comparison with Darlington's "Recent Advances in Cytology", first published twenty-five years ago and revised in 1937. In aim and scope the two books are very similar. Much new material has, of course, accrued since the earlier book was written, and the light of observation and experiment can now be thrown on questions which were then only beginning to loom ahead. Yet it is remarkable how often this later development is in some sense foreshadowed in the earlier work, and the two books are clearly talking about basically the same matters in essentially the same language. The real contrast between them lies rather in the author's approach. "Recent Advances in Cytology" sought to assemble the facts of chromosome behaviour and its genetical implications in terms of the comprehensive theoretical structure which Darlington has done so much to give to this science and which has provided the basis for its continuing development. Swanson, on the other hand, is content to ask questions and to give such information as is available about them, without pressing far into what he would doubtless regard as the speculatively theoretical in reaching answers. In consequence, to quote from his preface, "The reader will observe that few definitive answers can be given". Many will, no doubt, applaud this approach as permitting a fairer appraisal by letting the facts speak for themselves. To others it will be less obvious that this advantage can be counted on to follow, for left to themselves facts seldom fall into a complete or tidy pattern. Difficulty in reaching an answer can result from failure to confront the facts squarely with one another and reduce each to its true significance in relation to the rest. As Charles Darwin pointed out, theory supplies a guide to observation, and, even more to the present point, it can also stimulate the re-examination and reassessment of the 'facts' themselves. Obviously, no theory can be pressed in the face of recalcitrant but incontrovertible fact. But are all so-called facts of observation to be taken on their face value? Where everything fits except for some apparently stubborn observation, should the theory promptly be sacrificed? Or should not the observation first be re-examined in respect both of its validity and the significance attached to it? It is a rare observation which does not have some element of interpretation about it, and while to dismiss the observation out of hand simply because it is awkward is to miss the lead to truer understanding, to accept it unquestioningly on its face value is to invite frustration and confusion.

This problem of acceptance is well illustrated by Swanson's treatment of chromosome structure in relation to meiotic pairing. He dismisses a chemical theory of pairing proposed by Delbrück (p. 213) and also Darlington's precocity theory of meiosis (p. 212) on the ground that they are inconsistent with what he variously describes as the cytological fact and the idea that chromosomes are already divided and double at leptotene. The evidence from chromosome morphology suggests that each chromosome or chromatid may, in fact, be multipartite in structure, but what does this mean for chromosome function? We learn (p. 121) that the chromosome behaves to X-rays as though it were single during interphase

but double at mitotic prophase. Further, the evidence from deoxyribonucleic acid content (pp. 415–416) indicates that this doubles during interphase prior to mitosis, but that synthesis is not completed until zygonema (zygotene) or pachynema (pachytene) at meiosis. Now all that, for example, the precocity theory requires to provide its elegant account of behaviour at meiosis is the assumption that a division or doubling in the chromosomes, functionally effective in respect of their behaviour in pairing, takes place during interphase before mitosis but is not effected until pachytene at meiosis. The evidence of behaviour in respect of X-rays and deoxyribonucleic acid synthesis agrees with this; yet Swanson rules it out, without proposing any alternative, on the basis of static observations of chromosome morphology. Can such fully coherent evidence of behaviour be ruled out solely on that of structure, however valid the observations of morphology may be? Or should we not rather see the question as that of why a functional unit is structurally multiple and of how the structural entities are tied together into a single functional unit? Indeed, Swanson himself asks virtually this very question when he is considering structure in relation to X-ray effects. Further, he is prepared to accept the functional singleness of the chromatid when he is favouring Belling's hypothesis of how crossing-over comes about (a hypothesis, we may note in passing, with a serious intrinsic weakness in that, without subsidiary postulates, it fails to give an account of that most important feature of crossing-over, the occurrence of interference). It is thus not easy to share his rather surprising confidence that structural complexity puts at least singleness in respect of pairing properties completely out of court. The task is surely one of seeking to reconcile the evidence from behaviour and structure, of interpreting the physiological and the anatomical each in terms of the other, rather than of setting them in opposition as alternatives so that one or other must be abandoned.

The same problem of how function is related to structure is at the root of the lively discussions in progress to-day about the nature and organization of the gene. This has been repeatedly emphasized by Goldschmidt and others, and indeed it emerges, albeit somewhat sideways, from Swanson's account of chromosomes and genes. Yet one still feels that if he had been readier to grasp the theoretical nettle the reader would have emerged with a clearer idea of what is at issue, of where we stand and where we are heading, and with less of a sense of conflict than this chapter manages to convey.

Such comments could be extended to other parts of the book, and one might perhaps wonder whether the inclusion of a little more genetics, as, for example, when discussing the role of chromosome inversions in wild populations, would not have made clearer the significance of the cytological findings. These are, however, all comments on treatment, interpretation and opinion. The value of "Cytology and Cytogenetics" as a factual record is not in dispute. Misprints and misusages are few, and at least one reader quarrelled only occasionally with the author on the grounds of misleading statement or omission. This book will be widely used, and deservedly so, especially by postgraduate students of cytology and genetics; and if at times it provides them with the material for exercising their own judgment in questioning the author's conclusions, that is scarcely to be regarded as a defect.

K. Mather

RECENT RESEARCH ON PHOTOSYNTHESIS

Research in Photosynthesis

Edited by H. Gaffron, A. H. Brown, C. S. French, R. Livingston, E. I. Rabinowitch, B. L. Strehler, and N. E. Tolbert. (Papers and Discussions presented at the Gatlinburg Conference, October 25–29, 1955.) Pp. xiv+524. (New York: Interscience Publishers, Inc.; London: Interscience Publishers, Ltd., 1957.) 12 dollars.

MANY scientists at present actively engaged in research in photosynthesis met at Gatlinburg, United States, in 1955 to discuss their work and current problems. This book contains summaries of the papers presented, and in addition allows the reader to share some of the animation of the conference by printing much of the discussion which followed them. The editors are to be congratulated on producing a well-prepared, readable book from what must have been a confused transcript.

The book will be of the greatest value to the specialist. Largely due to the brilliant exploitation of carbon tracer in the study of photosynthesis the mechanism of the process can be now stated in broad biochemical terms. The remaining outstanding problem is the mechanism whereby light energy is converted to chemical-bond energy in the form of reducing power. This subject dominated the proceedings of the conference and was dealt with under five headings. First, the photochemistry of chlorophyll *in vitro* was discussed; a consideration of the primary photochemical process *in vivo* followed, largely centred on the analysis of spectral changes induced in photosynthetic cells during illumination and on studies of chemiluminescence of photosynthetic cells. The observed spectral changes could not be interpreted in terms of a change in the photosynthetic pigments alone; the changes in the yellow portion of the spectrum indicated the probable functioning of a cytochrome system. The possible role of cytochromes constituted the third topic and was extensively considered with reference to the photosynthetic bacteria, including the obligate anaerobe *Chromatium*. Another discussion was concerned with the reactions of chloroplasts after isolation from the green plant. The formation and condition of chlorophyll in the living cell were also considered. In addition, a section describing various physiological phenomena was included; much of this concerned the anomalous gas exchange which occurs immediately after the initiation of photosynthesis in the induction phase. It is a great convenience to have all these facets of photosynthetic research assembled in a single book.

Besides the large number of papers describing original work, three of the sections commence with a general review paper, and some others are scattered throughout the book. These are written with the object of introducing one specialist to the work of another, which is nowadays necessary even within a single field of research. Livingston's article on the photochemistry of chlorophyll *in vitro* is a valuable survey for the biologist; so also is Franck's paper on the possible role of an excited triplet state. The discussion following this latter paper emphasizes the difference of opinion between the physical chemist, who is greatly concerned with the difficulty of obtaining sufficient

energy from a single quantum for the transfer of an electron to the level of reduction of coenzyme, and that of the biochemist who prefers the simpler view that one electron is transferred per quantum. Kamen's article on the possible role of cytochromes is an excellent example of the biologist stating his view to the physical chemist. Such conferences as that at Gatlinburg fulfil a real need in stimulating discussion between workers from different scientific disciplines.

The general reader will find the book primarily of use as a source book of references. Unfortunately, from his point of view, it was not possible to include much of the work concerning the carbon metabolism of photosynthesis. The conference was intentionally limited to a detailed discussion of a few topics rather than attempting a complete survey.

C. P. WHITTINGHAM

NUCLEAR CHEMISTRY

La Chimie Nucléaire et ses Applications

Par M. Haïssinsky. Pp. vi+652. (Paris : Masson et Cie., 1957.) Broché, 5,000 francs ; Cartonné toile, 5,600 francs.

IT is fitting that the country in which radioactivity was first discovered should be the first to publish a major text-book which surveys virtually all the sciences and techniques in which radioactivity has come to play a part.

The first chapter, "La chimie nucléaire—ses grandes étapes", is an admirable account of the early work on radioactivity. There is the story of Becquerel's mystification over the strange trick of Nature that gave some uranium compounds both radioactive and strong fluorescent properties, and the way the Curies solved it in discovering the other radioactive elements : "la lucidité et la sûreté avec lesquelles ils ont advancé vers le but qu'ils s'étaient proposé, sur une voie jamais encore tracée". In this chapter there are included interesting pictures showing the blackening of the photographic plate which Becquerel first observed, and facsimiles of pages from the note-books of the Curies and of Rutherford.

Following this beginning, there are five chapters on the physical basis of radioactivity and three chapters on the radioactive elements, including the transuranium elements. The transuranium elements are divided into the 'uranides' (multivalent elements) and the 'curides' (mainly trivalent elements), but I feel this subdivision leads to words that sound badly in an English pronunciation, and it is not a clearly defined subdivision. These chapters lead up to the applications of radioactivity in geology and astrophysics, and there are good accounts of such problems as the determination of the age of the Earth. Following this, there comes a section comprising almost a third of the whole book, devoted to radiation chemistry. Separate chapters are given to the effects of radiation on gases, water and aqueous solutions, organic systems, solids and fluorescent systems. There is also a valuable chapter on the chemical effects associated with nuclear transformations. The last part of the book describes radioactive tracers and their applications and includes chapters on electrochemistry, reaction mechanisms, analysis, biochemistry and industrial processes.

A criticism of the book is that it attempts to make into one subject something that is really dispersed over a great many quite separate subjects. Nuclear chemistry in Britain, and in the United States, is normally regarded as a rather small subject restricted to a study of atomic nuclei and their reactions. Of this there is comparatively little in the book and it is discussed rather briefly. The chapters on radiation chemistry, on the other hand, constitute a major review suitable for a research student who would be interested neither in the nuclear problems, nor in the behaviour of radioactive tracers. The book is a notable attempt to bring order into a confused situation, but in practice, if the book were to be translated into English, it is not clear what type of student in Britain would find it useful.

The references are very full and up to date throughout the whole book, and in this respect the author has done a great service in assembling them. Minor criticisms are that there is no collated information such as a complete table of isotopes, or of cross-sections, and that the author index often lists several different people under one name by being restricted to one initial. There are also numerous typographical errors, particularly in such details as the alignment of subscripts, but errors in the actual text are very few for a book covering such a wide field.

G. N. WALTON

PAPER-MAKING

Fundamentals of the Beating Process

The Theory of the Development in Pulps of Papermaking Characteristics by Mechanical Treatment. By H. W. Emerton. Pp. xvi+198 (145 figures). (Kenley : British Paper and Board Industry Research Association, 1957.) 42*s*.

THIS volume refers to the mechanical treatment undergone by pulp fibres in preparation for paper making, and its author is principal research officer (physics) of the British Paper and Board Industry Research Association. It is addressed primarily to the paper-mill chemist, but it can also be read with much profit by all interested in fibre and cellulose science. A special feature is the numerous light- and electron-micrographs illustrating techniques of which Emerton is a recognized leading exponent.

Part I deals with the chemistry and structure of cellulose fibres. Part II covers the theory of beating (the most important and controversial chapter of the book), factors affecting the beating behaviour of pulp, methods for the determination of the progress of beating, and the effect of beating on the properties of paper. It is concluded that beating to produce strength increases the bonded area between fibres by making them plastic, so that they deform by surface tension during drying. Deformation provides the opportunity for bonding, the extent of which will depend on the degree of dispersion of the cellulose and other polysaccharides of the surface layer.

It will be seen that the general treatment is on a relatively elementary scientific plane, the purely practical mill aspects of the subject being deliberately excluded. There are a full index, and a liberal bibliography for the benefit of scientific readers outside the industry.

JULIUS GRANT

THE THEORY AND PRACTICE OF SHIELD DESIGN

Radiation Shielding

By B. T. Price, C. C. Horton and K. T. Spinney. (International Series of Monographs on Nuclear Energy. Division 10: Reactor Design Physics, Vol. 2.) Pp. ix+350. (London and New York: Pergamon Press, 1957.) 60*s.*; 10 dollars.

TWO books which deal solely with radiation shielding are now available to shield designers. Until the volume by Price, Horton and Spinney appeared, one had to be content with either a miscellaneous number of unrelated reports or the U.S. Atomic Energy Commission's "Shielding Design Manual", which while of great value as a comprehensive collection of data, remained very much a handbook. The first impression one obtains from the present volume is that a real effort has been made to put this untidy subject in order and, furthermore, a praiseworthy and generally successful attempt has been made to apply a fundamental and critical approach throughout. It is, in fact, a textbook on the subject, and although the theoretical interpretation and analyses, particularly those of Chapter 4, may appear tedious and complex to the engineer, they nevertheless form a substantial and reliable base from which to work into the future.

The book contains six chapters, the first of which deals briefly but adequately with the health physics aspects of nuclear radiation. The second analyses the attenuation of gamma rays and high-energy electrons and considers in detail the modes of interaction and sources of radiation. These effects are well understood and amenable to calculation except in so far as gamma build-up factors are concerned, and here the authors discuss the moments method due to Spencer, Fano, Goldstein and Wilkins. This, while applicable to massive bulk shields, which approach the idealized system for which the method was derived, is difficult to apply to the complex laminated shields of small mobile reactors and is likely in such cases to be subject to large errors. Nevertheless, this is a lucid chapter, as is Chapter 3, which presents the basic nuclear physics theory essential to any understanding of the problem of neutron attenuation. The following chapter, and perhaps the most important, deals with neutron attenuation in thick shields, and it is in the theoretical analysis of this aspect that the greatest uncertainties in shield design are to be found. The secret of success in the design of a reactor shield system, in terms of achieving the desired attenuation with minimum weight and cost, lies in the accuracy with which one can predict the neutron energy and spatial distribution in the shield. The authors advocate the use of a semi-empirical method based on age and diffusion theory using a fast group consisting of an integrated flux greater than 1 MeV. described by a simple attenuation process, an intermediate group described by an age kernel integrated over $1/E$ spectrum, and a thermal group described by diffusion theory. They show that good accuracy is obtained by this method for bulk concrete shields, but difficulty will again be experienced in applying it to the complex metal hydrogenous shields of small mobile reactors. One would have welcomed consideration of simple multi-group diffusion theory, which is showing promise as a straightforward and accurate method of predicting neutron distribution in this type of shield. This chapter also includes a section on the effects of ducts and voids in shields and provides a sensible treatment of a problem which has not generally been aired. Chapter 5 offers a well-balanced selection of basic mathematical formulæ encountered in shielding calculations. The engineering factors of shield design, including fabrication techniques, heating and thermal stress effects, and their inter-relationship with the physics considerations dealt with earlier, are discussed in Chapter 6. It is a necessarily compressed chapter but will be found to be of considerable interest. A genuine attempt has been made in the section on concrete to give guidance to design engineers in various practical matters, including the avoidance of cracks and streaming paths. Sections on the cost of shielding materials, induced activation of materials and coolants, on beam traps and shielding windows conclude the chapter.

The subject index is extensive and free of anomalies and each chapter is followed by an exhaustive list of modern references. This is a well-written and worthwhile book on a subject which has for too long been kept in comparative theoretical obscurity.

J. Edwards

GRAIN BOUNDARIES IN METALS

Grain Boundaries in Metals

By Dr. D. McLean. (Monographs on the Physics and Chemistry of Materials.) Pp. x+346. (Oxford: Clarendon Press; London: Oxford University Press, 1957.) 50*s.* net.

TECHNICAL metals are polycrystalline, and many of their properties depend on the grain boundaries. That is reason enough to have a book on the subject. But it takes five parameters to define merely the orientational relationships at a grain boundary: it is not very surprising that there is still no general exact theory of their behaviour. There has been progress, though, accelerating in the past decade. Some myths have been eliminated, the more sensible of the earlier ideas have won general acceptance, and a broad understanding has been attained within the compass of admitted approximations. If for nothing else, this book is to be welcomed as a reasoned index to the now very extensive body of literature on the subject. The free energies of grain boundaries and their effect in determining microstructure, the adsorption and diffusion of solutes at grain boundaries on intragranular deformation, grain-boundary migration, grain-boundary sliding and intergranular brittleness are all fully discussed.

The author is an efficient reporter of the work of others. His own contributions are for the most part sensible rather than penetrating. His grain-boundary model for the discussion of grain-boundary adsorption (three atoms thick, a mixture of three classes of atom sites, one-third large, one-third small and one-third normal) is probably worth still further detailed consideration for lack of a better. The author occasionally makes elementary mistakes. His claim on p. 50 to measure the line tension of a triple junction of grain boundaries is based on an obvious misconception of surface-tension phenomena—he should look at any liquid surface meniscus in a sharp corner. The subject of grain-boundary melting in pure

substances frequently gives trouble, and here is no exception. Somehow the author's thermodynamics teaches him (p. 100) that if λ_B and λ_{SL} are the free energies per unit area of grain boundary and of solid–liquid interface, respectively, then at some temperature below the melting point, at which ΔF is the free energy of melting per unit volume, a thickness $t = (\lambda_B - 2\lambda_{SL})/\Delta F$ should melt at the boundary, and he is left wondering why there is so nice a balance as there appears to be between λ_B and $2\lambda_{SL}$. He could have reflected that it is the property of a free energy to tend to a minimum, rather than to the value you first thought of, and $t\Delta F + 2\lambda_{SL}$ is minimum when t is zero. Nevertheless, by carefully reviewing all the experimental evidence he reaches the sane conclusion that grain-boundary melting has probably only been observed where there are impurities. A sharper-minded theoretician might have skipped the experimental evidence, to our loss.

F. C. FRANK

LATTICE DEFECTS IN IRRADIATED SOLIDS

Radiation Effects in Solids

By G. J. Dienes and G. H. Vineyard. (Interscience Monographs in Physics and Astronomy, Vol. 2.) Pp. viii+226. (New York: Interscience Publishers, Inc.; London: Interscience Publishers, Ltd., 1957.) 6.50 dollars.

THE production of various types of lattice defects in solids by the action of high-energy radiation, and the changes of physical properties brought about by these defects, have become in recent years one of the most actively studied branches of solid-state physics. This activity is a double response to the development of nuclear technology; on one hand, the experimentalist is now provided with sources of high-energy radiation far beyond those available fifteen years ago, and on the other he is expected to provide materials for nuclear reactors that are able to withstand intense radiations for long periods of time. The subject of 'radiation damage' is thus quite unique in the way that it links solid-state physics directly to both nuclear physics and the technology of materials.

Although several review articles have been published, this is, to the best of my knowledge, the first book that has appeared on the subject, and the authors are to be congratulated on a very successful outcome to their efforts. They have concentrated deliberately on effects of 'knock-on collisions', in which atoms are displaced from their lattice sites by particles such as fast neutrons, protons, electrons, and fission fragments, rather than on ionization effects. This is reasonable because these collisions are particularly important in nuclear reactors and because they can be exploited to study atomic binding forces in the solid state.

The book brings out clearly the tantalizing stage that the subject has now reached. Looked at qualitatively, or semi-quantitatively, the physics of radiation damage is fairly clear. The underlying theory of displacement collisions has been given a good start by Bohr and Seitz, and appears not to contain any major mysteries. Furthermore, the basic perfection of the crystal lattice has enabled us to define fairly sharply the nature of the various atomic defects that are possible, such as vacancies, interstitials, divacancies, and clusters; also, to understand in broad terms the ways in which they can move about and anneal themselves, and their effects on physical properties. The experimental study of annealing kinetics, and of changes in electrical resistivity, lattice constants, stored energy, and other properties, has also shown that this physical picture is certainly broadly correct. On the other hand, as soon as we ask for precise quantitative values, for example, for the numbers of displaced atoms, for the energies of formation and movement of the various defects, and for their effects on physical properties, the subject becomes difficult and progress is slow. Basically the reason is that we have very few techniques as yet for 'seeing' these lattice defects individually, with the result that their experimental study is mainly inferential, from changes of bulk properties, and uncertain. It seems doubtful that the subject will advance far beyond the semi-quantitative stage until new techniques are developed.

All these aspects are discussed clearly by the authors. The practical problems of radiation damage are less fully treated, although embrittlement of steel and radiation growth of uranium are mentioned, and an interesting account is given of the method used to anneal away the stored energy in the graphite moderator of the Brookhaven reactor. Transmutation effects, and the interesting behaviour of inert gases in solids, are not discussed; this is a pity, although it may perhaps be argued that the important aspects of these belong more to the theory of solid solutions than to the theory of lattice defects.

In conclusion, this book can be recommended as a useful introduction to the physics of radiation damage in solids.

A. H. COTTRELL

HYDRAULIC SYSTEMS IN AIRCRAFT

Aircraft Hydraulics

Vol. 1: Hydraulic Systems. Edited by H. G. Conway. Pp. ix+146. 35*s*. net. Vol. 2: Component Design. Edited by H. G. Conway. Pp. ix+198. 45*s*. net. (London: Chapman and Hall, Ltd., 1957. Published under the authority of the Royal Aeronautical Society.)

THESE two volumes are text-books sponsored by the Royal Aeronautical Society; and several well-known authorities in the aircraft hydraulics field have contributed chapters on their own special subjects. These have been edited by Mr. H. G. Conway, who also contributes himself.

Vol. 1 deals with the more general aspects of the subject. Mr. Bingham, in Chapter 1, discusses the requirements for an aircraft hydraulic fluid and then goes on to deal with the properties of various fluids. Their effect on different sealing materials, storage and inflammability characteristics, etc., are described, and a very useful collection of graphs and tables of the physical properties of these fluids is also provided.

In Chapters 2 and 3 Mr. Collinson deals briefly but effectively with hydraulic theory and fluid flow in orifices and pipes, providing some useful nomograms and charts for determining rates of flow. There are sections on surface tension, viscosity, com-

pressibility and Bernoulli's theorem, to mention only a few. A brief account is included of the gas laws, with which one is obviously concerned when designing accumulators or air bottles.

Next Mr. Parker and Mr. Conway discuss hydraulic systems and circuits. It is obviously impossible to lay down a set of rules for designing a complete system in a text-book; but in Chapters 4 and 5 various aspects, including pumps, piping, jacks and circuits, are considered and sound advice is given on both desirable and undesirable features for a system.

Finally, Mr. Black considers the installation, operation and testing of a hydraulic system in an aircraft. He very wisely emphasizes the importance of good filtration and careful attention by operating personnel to clean working methods and conditions, and in the section on fault-finding he warns the reader never to assume that a component is too simple to go wrong. Mr. Black also discusses the design and use of full-scale rigs for ground-testing complete hydraulic systems, prior to flight-testing in prototype aircraft.

Vol. 2 deals in detail with components for aircraft hydraulic systems. Separate chapters are devoted to seals, pumps, jacks, servo-controls and many other devices. Space limitations preclude a detailed review of each of the subjects treated, but it may suffice to say that they are all discussed and explained thoroughly. The book abounds with sectional drawings and diagrams of components made by both British and foreign firms; the information given is remarkably complete and represents hard-won and up-to-date experience.

These volumes cover the whole field of aircraft hydraulics and yet the individual subjects are treated so thoroughly that a very good working knowledge is obtained. Particular emphasis is placed on the practical aspects throughout, but this is backed by suitable theoretical explanations. These books can be recommended highly and should prove very valuable to students or technicians starting work in this field. They should also be useful to those more experienced specialists who may wish to refresh their memories on the other man's problems.

THEORY OF SOLUTIONS

The Molecular Theory of Solutions

By Prof. I. Prigogine, with the collaboration of A. Bellemans and V. Mathot. (Series in Physics.) Pp. xx+448. (Amsterdam: North-Holland Publishing Company, 1957.) 48 guilders.

IN theoretical physics it is often more useful to circumvent an intractable problem than to solve it; this is nowhere more true than in the statistical theory of solutions. In principle (as can so often be claimed) the thermodynamic properties of any mixture of molecules are determined precisely by the intermolecular potentials, and one should, therefore, be able to calculate the equation of state from a knowledge of intermolecular forces alone. In practice, however, this is a fruitless undertaking except at densities so low that a virial expansion can be performed with accuracy. Our failure to construct an exact theory of the liquid state is a sufficient indication of the hopelessness of attempting an *a priori* theory of liquid solutions. It therefore becomes pertinent to ask: What should be the aim of theories of solutions and how are we to judge their success or utility? Only to ask this question suggests a promising line of attack. The primary aim of solution theories must be to express in terms of the relevant intermolecular potentials the change in free energy which accompanies the mixing of pure fluids with one another. In order to yield useful results the theory of solutions must, therefore, make full use of the experimental properties of the pure components under conditions which resemble as nearly as possible the condition of the solution itself. This philosophy, in recent years, has led to notable advances, and these are fully and carefully described in Prof. I. Prigogine's book.

Of particular interest in solution theory are mixtures of molecules the intermolecular potentials of which are of the Lennard-Jones type, leading to a short-range repulsion and a long-range attraction. Pure species of this sort obey the law of corresponding states, and this law can be generalized to mixtures of Lennard-Jones molecules provided their force fields are isotropic, and do not differ too greatly in strength. The theory of such mixtures, now known as 'conformal solutions', must, however, be extended in order to describe adequately the properties of mixtures in which there are specific interactions or in which the molecules are of very different size. Prof. Prigogine and his colleagues have been largely responsible for this expansion of the theory, and have also accounted successfully for the properties of special classes of mixtures such as associated solutions, mixtures of isotopic species, and certain types of polymer solution.

The mathematical methods used in the book are sufficiently elementary to be followed by the ordinary physical chemist, and the book contains many numerical examples which enable the reader to test his understanding of the theory. The physical arguments are clearly and fully expounded and there is much valuable new material which has not yet appeared in the literature. Altogether this is a thoroughly up-to-date and critical book which can be warmly recommended to those wishing to acquaint themselves with the most important recent developments in the theory of non-electrolyte solutions.

H. C. Longuet-Higgins

SOLUTION OF EIGENVALUE PROBLEMS

Variational Methods for Eigenvalue Problems

An Introduction to the Methods of Rayleigh, Ritz, Weinstein, and Aronszajn. By Prof. S. H. Gould. (Mathematical Expositions, No. 10.) Pp. xiv+179. (Toronto: University of Toronto Press; London: Oxford University Press, 1957.) 48*s*. net.

IF H is a linear operator, the values of λ, real or complex, for which the equation $Hx = \lambda x$ has solutions in x satisfying given boundary conditions, are the eigenvalues of the equation.

If the space of the elements x is finite-dimensional, the eigenvalues can be obtained by standard methods; but these methods may become impossibly difficult when this space is infinite-dimensional (for example, Hilbert space), and it is then that the variational method is of great value in many practical cases. This consists in finding the minima of certain expressions associated with the above equation. If now we

introduce more stringent prescribed conditions, then the desired minimum will be raised, or at least not lowered, and we obtain upper bounds for the eigenvalues of the original problem; this is the essence of the well-known Rayleigh–Ritz method. If, instead, we weaken the prescribed conditions, the minimum will be lowered, or at least not raised, and we obtain lower bounds for the desired eigenvalues; this is the essence of the Weinstein method. Aronszajn then dealt with the question as to whether these successive approximations actually converge to the desired eigenvalues.

Prof. S. H. Gould's book sets forth in an admirably clear way the details and proofs of the above, together with practical applications to vibrating rods, membranes, and plates.

The ten chapters are on: systems vibrating with a finite number of degrees of freedom; variational principles for finite-dimensional systems; vibration of systems with infinitely many degrees of freedom; reproducing kernels and functional completion; vibrating rods, membranes, and plates; the Weinstein method in its original form; linear operators in a Hilbert space; the Weinstein–Aronszajn method for linear operators in Hilbert space; application of the Weinstein–Aronszajn method in Hilbert space to the differential problem of the vibrating plate; application of the approximate methods to general differential problems.

The general theory is of interest to the pure mathematician, while the applications will interest the applied mathematician and physicist.

The book makes a valuable contribution in setting forth the above ideas and theories in a systematic way, and it is easily readable by any good post-graduate student. R. G. COOKE

RECENT ADVANCES IN APPLIED MATHEMATICS

Modern Mathematics for the Engineer

Edited by Prof. Edwin F. Beckenbach. (University of California Engineering Extension Series.) Pp. xx+514. (London: McGraw-Hill Publishing Company, Ltd., 1956.) 56*s*. 6*d*.

A CARELESS glance at the cover of this book might lead the reader to expect a text-book on engineering mathematics similar, perhaps, to Kármán and Biot's well-known "Mathematical Methods in Engineering". However, the important word in the title is "modern", as the book is actually a collection of mathematical essays describing some of the developments which have taken place in mathematics during the past fifty years. Each essay is by a different author, and the contributors include such distinguished mathematicians as Solomon Lefschetz, Richard Courant and Norbert Wiener.

The subject-matter is divided somewhat arbitrarily into three sections. The first, entitled "Mathematical Models", is largely concerned with the theory of ordinary and partial differential equations, and most of it will be familiar to anyone with a training in mathematical analysis. There is a chapter on non-linear vibrations, an account of the calculus of variations, and chapters on elliptic and hyperbolic partial differential equations. The use of complex variable methods in problems of plane elasticity is dealt with in sixteen pages, and there is also a short survey of exterior ballistics.

The second section covers less familiar ground, as it deals with problems which the editor calls "Probabilistic". It begins with an account of prediction theory, and the subsequent chapters cover the theory of games, operations research, dynamic programming and Monte Carlo methods. In spite of the title, there is no account of ordinary statistical theory. Much of the material in this section is new, at least in the sense that it is not usually found in general text-books on mathematical analysis.

Although the final section is entitled "Computational Considerations", a considerable part of it might well have been included in Section 1. The chapters on non-linear analysis and relaxation do include some details of computational techniques, but the sections on matrices, conformal mapping, and functional transforms are devoted entirely to analysis. It is worth noting that the chapter on "Methods of Steep Descent" describes techniques for minimizing a function in n-dimensional space, and is not an account of the 'method of steepest descents' used in the evaluation of contour integrals. The final chapter deals very briefly with high-speed computing devices.

To say that this is a book for engineers is misleading, except in the sense that almost any part of mathematics may have some engineering application. There are few references to engineering problems, and indeed one contributor admits to having very little contact with engineering. But whether the reader is an engineer or not, he is certainly expected to be a competent mathematician. Most of the contributors have tried to present concise yet comprehensive surveys of their chosen subjects, and to do this they have necessarily had to assume a good working knowledge of the main branches of mathematical analysis.

Although all the chapters are well and authoritatively written, there is little cohesion between the various sections. The most valuable parts of the book are probably those describing topics such as game theory in which there are at present considerable developments, and where it is difficult for the newcomer to find his way. The lists of references attached to these chapters will be especially useful. It is less easy to justify the inclusion of sections on such well-known subjects as matrices and the calculus of variations, where there is already no shortage of easily available literature. R. K. LIVESLEY

MATHEMATICS IN SECONDARY SCHOOLS

The Teaching of Mathematics

(Issued by the Incorporated Association of Assistant Masters in Secondary Schools.) Pp. ix+231. (Cambridge: At the University Press, 1957.) 15*s*.

THIS volume, the seventh in a series, concerns itself mainly with a general consideration of the purpose of teaching mathematics in secondary schools. The Committee expresses frankly its lack of authority to comment upon the work in secondary modern schools, though it has a good deal to say about the methods of teaching arithmetic in primary schools. Great stress is laid on the needs of the pupil in relation to the substance and not to the structure of the subject, and the old theory of 'transfer of training' is firmly rejected. Nunn's contribution to this change of emphasis receives full

consideration, and reference is made to the effect of the Jeffery Report (printed in full in an appendix).

Two detailed chapters develop the work up to the ordinary level of the General Certificate of Education, and the failure of some pupils is regarded as due to unsuitable teaching methods in primary schools. A suggested minimum syllabus for this pre-entry course is given, with a lengthy discussion of the work of the first five years in the grammar school. "Some General Teaching Topics" contains much material for careful consideration by all engaged in teaching mathematics. Far too many men and women are gallantly tackling work which is beyond their own capability as teachers, and this chapter should be of great value to them.

The chapter on the sixth form is less successful than the rest of the book, and it suffers from an attempt to deal with a big topic within the compass of 25 pages. Although expansions and infinite series come into the basic course there is no mention of the vital question of convergence. There is no mention of mass in the basic mechanics course, though one of the main teaching points in school mechanics is surely the distinction between mass and weight. In the section on analytical geometry the correspondence between a locus and an algebraical equation is developed; it could well have been extended to the realization that the curve separates the plane into areas in which the function is either positive or negative; $f(x) > 0$ can be so much more interesting than $f(x) = 0$.

There is a sensible discussion of the mathematical library, with a good list of suitable books, and elementary books in foreign languages are recommended though none is quoted.

The place of practical work in the mathematics course receives serious attention, and a mathematics room with workshop is suggested.

Lastly, a strong plea is made for the inclusion of statistics in the school course. Even if the scope of the work given here is over-ambitious, the conclusion "that statistics, so long as it is taught as a practical subject, can help to make school mathematics more realistic" well expresses the attitude to this relatively new school subject.

Some fifteen misprints have been overlooked in this first edition, but the Association can expect confidently to need a reprinting very soon. The volume as a whole is of the standard that is expected from the Cambridge University Press. W. J. Langford

A POPULAR ACCOUNT OF RADIO-ASTRONOMY

The Changing Universe

The Story of the New Astronomy. By John Pfeiffer. Pp. xi+244+16 plates. (London: Victor Gollancz, Ltd., 1956.) 18*s*. net.

WE are very familiar to-day with the problem of communications between scientists and the general public, and we have recently seen considerable and successful efforts in daily and monthly journalism to provide intelligent reporting of the more exciting scientific work of the present day. A more difficult problem is set by the popular text-book, which attempts to explain a whole subject to a reader whose only background is an intelligent, but rather vague, interest. An author determined to write such a book must face rigid restrictions—no mathematics, no formulæ, are allowed; all difficult terms such as frequency, wave-length, galaxy, must be explained.

Pfeiffer has written such a book, and in it he manages to cover the whole of radio astronomy up to the middle of 1956. He started with the severe restriction of knowing no radio-astronomy at all, but he had instead the advantages of twenty years experience of scientific journalism, and of two successive tenures of a Guggenheim Fellowship which enabled him to visit and talk at some length with many of the leading radio-astronomers. His account stems directly from his interviews with the men who did the work, and the history of the subject which he provides is the best we are likely to have for some time. The book is accurate in its facts; so accurate and in sufficient detail, that it can seriously be recommended as an introduction to radio-astronomy.

The contrast between the accuracy and interest of subject-matter, and the style of writing, is remarkable. Mr. Pfeiffer is an optimist. He believes it is possible to explain radio astronomy in all its complexity to anyone able to read, and he consequently addresses himself to a public whose attention requires to be riveted to each page separately by the use of superlative, hyperbole, and simile. It is safe to say that no radio-astronomer could have written such a book, although such a style would, from them, be appropriate to short magazine articles or popular lectures. I find the style too obtrusive for comfort in such a large dose, and I would be surprised to find anyone who needed such a continuous stimulation of interest and who yet was able to read and appreciate the whole of the book. F. G. Smith

INTO SPACE

Satellites and Space Flight

By Eric Burgess. Pp. vii+159+14 plates. (London: Chapman and Hall, Ltd., 1957.) 21*s*. net.

THIS book traces the expected future history of space-travel, from the instrumented artificial satellites which are already in being to the manned interplanetary space-ship which, Mr. E. Burgess thinks, may not come for fifty years or more. The first chapter deals with rocket motors, the dynamics of satellite orbits, and the scientific experiments which can profitably be made in unmanned satellites. The next step into space is the unmanned 'probe' missile, sent to investigate the Moon and Mars on our behalf. Mr. Burgess discusses possible circum-lunar orbits, the optimum transfer ellipse from Earth to Mars, and the design and instrumentation of a lunar-probe missile. Man's first sojourn in space will probably be inside a satellite space-station, and once he feels at home in this remote outpost, his next goal will be the Moon. For, despite its unattractive climate—a near-vacuum with extremes of temperature—the Moon will be prized as a base because it occupies a favourable niche in the hill-and-valley system of gravitational potential. Mr. Burgess describes the problems of the lunar base built either above or below ground, and outlines what is known of the Moon's surface. The last chapter, on manned interplanetary travel, includes a discussion of nuclear and ion rockets, and ends with some gentle speculation on interstellar flight.

Mr. Burgess, a seasoned campaigner in the realms of interplanetary space, is a confident guide, and his prophecies may well come true, if taxpayers choose

to let their money be spent on space-travel. He is familiar with all the literature on the subject, and he gives a useful list of references at the end of each chapter. He steers a wary course half-way between a popular exposition and a text-book. Though he is careful to avoid mathematical symbols, he does not shirk detail: there is plenty of numerical grist, indeed perhaps rather too much, since all weights and distances are expressed in both English and metric units. This practice has something to be said for it, however, in a subject like space-travel, where the applied scientist, a slave to slugs, has to co-operate with his purer, gram-bound colleague.

In the choice of subject-matter there is little need for improvement, but it is a pity that the same cannot be said for the style of writing. Mr. Burgess can find the happy phrase when he tries, but at times he is content to be slipshod and repetitive, and occasionally it is none too clear what he means. Apart from this intermittent failure to communicate, Mr. Burgess is usually a reliable guide to the untrodden paths of space. But he is not infallible, and it has to be said that the book is marred by too many minor mistakes: on p. 97 and elsewhere he repeats the crucial error which misled the interplanetary theorists for so long, namely, their belief that the weight of structure and motor on any missile (or stage of a missile) could not be much less than 20 per cent of the total, though even in 1952 the *Viking* achieved 15 per cent; p. 63 needs thorough revision; Fig. 1.2 is in error; and there are more than thirty other trivial errors or misprints. D. G. KING-HELE

LOGICAL STUDIES AND INDUCTION

Logical Studies

By Prof. Georg Henrik von Wright. (International Library of Psychology, Philosophy, and Scientific Method.) Pp. ix+195. (London: Routledge and Kegan Paul, Ltd., 1957.) 28*s*. net.

The Logical Problem of Induction

By Prof. Georg Henrik von Wright. Second revised edition. Pp. xii+249. (Oxford: Basil Blackwell, 1957.) 25*s*. net.

A REVIEW of these two volumes together may serve to show the range and depth of Prof. G. H. von Wright's thinking. His "Logical Studies" comprises a series of eight papers—five of them published previously—and the "Logical Problem of Induction" is essentially his *doktor-arbeit* submitted to the University of Helsinki in 1941. The present book is a second, enlarged edition of the original work published as Vol. 3 of *Acta Philosophica Fennica*.

With regard to the "Studies", three essays are presented dealing with the problem of logical truth. This amounts to an attempt to clarify the statement that logical truth is at root a tautology; or otherwise expressed, that logical truth is a function of form but not of content. It is valuable to have this theme so competently handled. A general lack of understanding about it may well be one reason (no doubt there are others) why scientists are apt to complain that philosophers do little beyond echoing and complicating the less secure tenets of physical theory. Until some crucial issue focuses attention upon it, experimentalists in particular are naturally reluctant to take seriously a discipline which makes rigid demands upon the structure of ratiocination but has nothing to say concerning that which is in fact the subject, the thing-in-itself as Husserl would insist, and its associated correlates.

Underlying this dilemma is the failure to allow enough for the æsthetic content of each problem, whether scientific or logical. Mere applications or developments of existing knowledge are unlikely to prove coercive, since they rarely provide an opportunity for that contemplative factor which lifts the best human efforts above the useful and the pragmatic. It is for this reason that those about to embark upon any postgraduate course of study or research would find it rewarding to read the first chapter in this collection, namely, "Form and Content in Logic".

The next group of contributions is concerned with modality: it should have a wide appeal because of the relationship to probability and the study of norms. But perhaps the most interesting point here is the recognition that there can be—and actually is—a new modal logic which is relative rather than absolute, in the classical sense. The author maintains the Aristotelian origin of this distinction, namely, ὑποθέσεως against ἁπλῶς. Lexicographically, the emphasis of the former is upon 'that which is under', whereas the latter stresses simplicity or singleness. It would have been helpful if Prof. von Wright had enlarged upon this theme a little, because it would have strengthened his assertion that the relative should include the absolute as a limiting case. The concluding study (the concept of 'entailment') bears an epistemic slant, and gives a broad hint of how close we are to the notion of demonstratability.

Turning now to the "Logical Problem of Induction", this largely follows traditional lines in discussing any respectable justification for that which we all take for granted, and upon which so much of everyday life is based. The upshot is that, broadly speaking, induction cannot be rigorously defended, although this result does not necessarily involve such disastrous consequences as are sometimes feared. Prof. von Wright's treatment of this situation is as follows. The basic thesis is presented in the form, "It is impossible to guarantee, with certainty or with probability, that an unknown instance of the property A will also exhibit the property B, if A and B are different properties". (We may perhaps compare this with other 'postulates of impotence' such as that relating to electrostatics or with the second law of thermodynamics, or even with the negative existential quantifier $\sim\exists$, "there does not exist ...".) It appears that, on contrasting a single statement with truth-frequency for a class of statements, it is reasonable to delete "with certainty or with probability". But criteria of the truth of inductive instances cannot be demanded, though this does not preclude the acceptance of 'symptoms' as applied to experience. Embedded in the whole domain of human thought is the temptation to confuse issues of language and of fact. The classification of the former as a lemma to the solution of Hume's problem is the critical task of philosophy, in contrast to the constructive task with its focus upon given conceptual structures. The analysis of inductive propositions can then be undertaken on mathematical principles. Constructive philosophy is not the tool to use for dealing with Hume's scepticism; it has sufficient material upon which to work in its own field, for which Prof. von Wright has provided a sound foothold, as well as a springboard for inductive studies.

F. I. G. RAWLINS

DAIRY RECORDS

Milk and Butterfat Recording

A World Survey. By E. D. Ashton. (Technical Communication No. 3 of the Commonwealth Bureau of Dairy Science and Technology.) Pp. x+197. (Farnham Royal: Commonwealth Agricultural Bureaux, 1956.) 30*s*.

THE only previous publication dealing comprehensively with this subject was that of the International Institute of Agriculture in 1935. Since then considerable progress has been made in methods of milk and butterfat recording and in the use made of such records, and the number of officially recorded cows has increased from 4½ million to the present figure of approximately 8 million.

This survey is a welcome and highly informative contribution to agricultural literature. The history and development of milk recording in some thirty countries is presented in a concise and comprehensible form, as are the financial and administrative problems inherent in the different systems of milk recording operating under the varying conditions which prevail in these countries.

The book appears to fall naturally into two parts: a general survey of the present state of milk and butterfat recording and a series of detailed accounts of the milk-recording movements in specific countries.

Chapters in the first part trace the development of milk recording from the small beginnings of private and breed society records to the start of official milk recording in Denmark in 1895 and on to the present position wherein more than thirty countries have official milk recording schemes and between one-quarter and one-half of the dairy cows in the main dairying areas of the world are officially recorded. Organization of milk recording and methods of financing these movements are discussed very fully as are the practical aspects of milk recording such as identification of cows, methods of sampling, butterfat testing and milk recording personnel. An extremely interesting chapter is devoted to the use of milk recording on and off the farm, in feeding and breeding policies, and another presents the interest of international organizations in milk recording as a means of increasing economic production of milk to help meet the nutritional needs for animal protein in many parts of the world. In the final chapter of Part 1, the author links the future progress of milk and butterfat recording with other services of livestock improvement. An addendum to the first part comprises an excellent review of the literature on methods of milk recording.

The second part of this survey is devoted to milk-recording movements in different countries. The countries covered include the older agricultural countries of Europe, the newer agricultural countries such as Australia, Canada, New Zealand, Southern Rhodesia, the Union of South Africa and the United States of America and tropical and sub-tropical countries such as India, Israel, Jamaica, Japan, Pakistan, Kenya, Tanganyika, Uganda and Nigeria. Concise information is given concerning the national dairy herd, the development of milk recording, its organization and practice in these countries. Each country has its own particular problems and a system of milk recording which proves satisfactory in one is not always the most suitable in another.

Each section contains a summary and a list of references and there are forty-three illustrations. As might be expected in a book of this nature, there are a number of figures and tables. These are clear and well set out and are most informative. In addition, there are a number of useful appendixes.

The author is to be congratulated on assembling such a fascinating account of the world's dairy herds. The publication is of real value to all those seeking information about methods and achievements of milk recording, whether their interests lie in well-developed agricultural countries or in countries where such developments are growing or are yet to come.

HELEN R. CHAPMAN

SUSPENSION BRIDGES

The Theory of Suspension Bridges

By Sir Alfred Pugsley. Pp. vii+136. (London: Edward Arnold (Publishers), Ltd., 1957.) 42*s*. net.

THE several theories of suspension bridges are presented concisely and clearly in this book together with the principles of the study of the vibration of this type of structure.

After an interesting historical introduction to the subject, there are two chapters on theories of the simple suspended cable, including the analysis of stresses and deflexions for various conditions of loading. The well-known approximate theory due to Rankine is the first of the theories of suspension bridges dealt with in the book. Rankine assumed that the cable is parabolic and inextensible, that the deck girders are rigid and that live loading is distributed uniformly to the cable by the girders. This is followed by an account of the elastic theory due initially to Navier and developed more recently by Steinman, which is an improvement upon Rankine's theory only in respect of the allowance for the elasticity of the cable and girder in the determination of the intensity of uniformly distributed loading on the cable. Finally, the more accurate deflexion theory derived by Melan on the basis of the differential equations of the cable and stiffening girder and its approximation—the linearized deflexion theory due to Godard—are considered. The deflexion theory as developed in the United States by Moisseiff and others has proved extremely valuable for predicting the behaviour of modern long-span suspension bridges. In his treatment of the linearized deflexion theory, the author includes the use of trigonometrical series as well as his own contribution, the flexibility coefficient approach. The use of the former for solving the equations of the general deflexion theory in the manner proposed by Timoshenko and Steuerman is described in a separate chapter.

There is a useful chapter summarizing approximate methods of analysis for preliminary design, which is followed by two chapters on the vibration aspect. The collapse of Moisseiff's Tacoma Narrows bridge in 1940, due to aerodynamically induced vibrations, emphasized the importance of this phenomenon to the designers of long-span suspension bridges. Thus, Chapter 11 deals with the prediction of natural frequencies and modes of vibration in flexure and torsion, while the final chapter gives an abbreviated treatment of the problem of vibration of suspension bridges due to lateral winds, including the use of scale-model tests.

The book is unique among British works on theory of structures, and its conciseness and lucidity are admirable. It is clearly set-out and contains references to original papers and a select bibliography.

T. M. CHARLTON

The Relationships Between Electroencephalographic and Psychological Data in Normal Adults

Dr. P. F. Werre. Pp. vii+152. (Leiden: Universitaire pers Leiden, 1957. Distributed by Messrs. Martinus Nijhoff, Lange Voorhout 9, The Hague.) 15 florins.

BERGER'S discovery of the potential changes in the brain, which he first published in 1929 and which was confirmed by Adrian and Matthews in 1954, led automatically to the foundation of the science of electroencephalography. Its value was realized when Gibbs, Gibbs and Lennox showed that epilepsy could be revealed or confirmed by the electroencephalogram, and this was further enhanced by its use by Jasper and Walter in locating brain lesions. In the Second World War the electroencephalograph was regarded as a valuable instrument in the localization and assessment of brain damage, mostly of traumatic origin. To the neurologist it is now almost as valuable as X-rays to the surgeon. The next step in the use of electroencephalography is obviously to unravel the problems of psychology. A certain amount of work has been done on patients suffering from psychopathic personalities but much remains to be discovered with normal people in such mental states as frustration, anxiety, insecurity, anger and depression. The aim of this thesis is to record some of this work performed by Dr. P. F. Werre in the Neurological Clinic of the Academic Hospital at Leyden.

The book consists of three parts, comprising a survey of the literature, records of experiments and conclusions. In his survey the author considers the literature on electroencephalographic findings in sleep, emotion, anxiety, fatigue and relaxation, the effect of sensory stimulation and mental activity, etc. In the records of his experiments he discusses its relation to the psychology of the subjects. He is cautious in his conclusions but thinks that some definite psychological grouping of people on the basis of the electroencephalogram can be made. This seems to be particularly so in such matters as social insecurity and frustration. All those interested in electroencephalographic work will wish to read this book. Indeed, it is valuable if only for the bibliography, which covers eighteen pages, and for the survey of the literature which occupies sixty-one pages. Although the experiments were conducted on only a small number of subjects the tentative conclusions offered are very suggestive.

CLIFFORD ALLEN

Reason and Chance in Scientific Discovery

By Dr. R. Taton. Translated by A. J. Pomerans. Pp. 171+32 plates. (London: Hutchinson and Co. (Publishers), Ltd., 1957.) 30*s*. net.

IT is gratifying to see an English translation of Taton's dissertation on the art of scientific discovery. This is, of course, by no means the first attempt to analyse the operation of the creative process; but many of the Continental examples of originality selected by the author for analysis are perhaps new to many British readers. Relying largely on case-histories, the accounts of which are well illustrated by diagrams and many excellent plates, Taton discusses such matters as intuition, the automatic and unconscious activity of the human mind, the power of new instruments and the role of chance and accidental observations in the furtherance of human knowledge. It is, indeed, an exciting theme so long as the reader of these post-mortem analyses does not count it all to be an infallible prescription for discovery. Too often the discoverer, in retrospective self-analysis, is apt to conceal the amount of what Katherine Mansfield calls the "terrific hard gardening"—the laborious, conscious and voluntary informing and equipping of the mind which must precede the break-through on the scientific front. As for the great significance of being able to recognize the unexpected, it is relevant to recall the dictum of Pasteur that chance favours the prepared mind. Still, Taton's book is a scholarly contribution to scientific history, and might, for example, be recommended for parallel reading with Brewster Ghiselin's excellent book on the creative process in the world of music and letters.

EDWARD V. APPLETON

The Transformations of Man

By Lewis Mumford. (World Perspectives.) Pp. 192. (London: George Allen and Unwin, Ltd., 1957.) 15*s*. net.

IN this book the author, in seven successive chapters, analyses the transformations of man in a series of stages from his animal or pre-human existence, through what Mumford classifies as archaic man, civilized man, 'axial man', of the 'axial' or universal religions, old world man of the Old World societies, new world man of the New World, to 'post-historic' man of the present time. Pointing out that man's humanity is now threatened by the possibility of barbarism more elemental than was ever encountered in historic times, he postulates the need of a world culture, and that man's principal task to-day is to create a new self, adequate to command the forces that now operate so aimlessly and compulsorily. He believes that humanity still has the technological, as well as the spiritual and personal resources, to create a future which offers scope to human personality, and in his final chapter, "Human Prospects", attempts to indicate something of what is involved in checking the present dissipation of man's potential energy, vitality and creativeness and turning them to this purpose.

To readers of this series that began with "Technics and Civilisation" and ended with "The Conduct of Life" this will be a disappointing book. Neither in scale nor in execution does it match the earlier books. It is more difficult to read, and neither the philosophy nor the argument is expounded with the coherence and cogency that are demanded of an author who assays to cover his field on his own authority essentially unsupported by citation or reference.

Veterinary Toxicology (formerly Lander's "Veterinary Toxicology")

By R. J. Garner. Pp. vii+415. (London: Baillière, Tindall and Cox, Ltd., 1957.) 35*s*. net.

THE radical changes that have occurred in the sources of toxic hazards to animals can be seen in comparing the present volume with the early editions of its forerunner, Lander's "Veterinary Toxicology". In the latter, more than half the book was devoted to poisonous plants, while in addition, the majority of organic poisons described were of plant origin. Now plants form but one of six sections in the book, and it is clear that the domestic animal must face a barrage of synthetic compounds largely comprised of the herbicides used to destroy the plants themselves. Perhaps in future editions it will

be necessary to expand the present short but valuable section on radioactive materials. The situation is summarized in the introduction, where common causes of poisoning are tabulated. It is to be regretted that this section of the book is not fuller and indeed that more statistics are not available. This lack of information, which was emphasized by the Zuckerman Report on Toxic Chemicals in Agriculture, necessarily limits the effective direction of policy to reduce the incidence of poisoning.

The author has organized his voluminous material in an admirable way; inorganic substances are dealt with in alphabetical order, but this codical system has been dropped in considering drugs and pesticides. However, this allows the rational grouping of agents with similar modes of action, and hence economy in the text: it is the approach that is familiar in experimental pharmacology. The whole book is well documented with references which will be of value to practitioner and student alike, and indeed the general sections of the book could be read with advantage by students at their preclinical stage.

P. JEWELL

Jets, Wakes, and Cavities

By Garrett Birkhoff and E. H. Zarantonello. (Applied Mathematics and Mechanics: a Series of Monographs prepared under the auspices of the Applied Physics Laboratory, Johns Hopkins University, Vol. 2.) Pp. xii+353. (New York: Academic Press, Inc.; London: Academic Books, Ltd., 1957.) 10 dollars.

WHILE the subject of jets, wakes and cavities is of considerable interest in fluid dynamics and has attracted the attention of many engineers, physicists and mathematicians, accounts of the field as a whole are very rare. Thus, the attempt to collect the available information in one volume is most welcome, and from this aspect alone the book under review with its almost overwhelming number of references is extremely useful. But since the first author, in particular, has himself contributed much original work to this subject, the presentation bears his stamp and draws together and co-ordinates many fragmentary and seemingly unrelated pieces of information. A wide and complex field is covered and interest in the subject is still very much alive. It is in these still vigorously growing branches that the authors' preferences are most apparent and, perhaps, lead to a slightly one-sided presentation. Altogether, the book affords an excellent introduction to a fascinating subject and will profitably be studied by graduate students as well as general readers who are curious about applied mathematics, hydraulics, or aeronautics.

D. KÜCHEMANN

Nuclear Reactors for Research

Edited by Clifford K. Beck. (The Geneva Series on the Peaceful Uses of Atomic Energy.) Pp. xii+267. (Princeton, N.J.: D. Van Nostrand Company, Inc.; London: D. Van Nostrand Company, Ltd., 1957.) 8.50 dollars; 64s.

SO much information was presented in such a short time at the 1955 Geneva Conference on the Peaceful Uses of Atomic Energy that several publishers recognized the need for producing edited collections of papers on particular topics. The book under review is such a collection. In Part 1 the uses of research reactors are first discussed and illustrated by extensive references. Descriptions of particular types of research reactors are given in subsequent chapters which comprise Part 2.

Most of the material in the book has appeared elsewhere, but Dr. Beck has made deletions and rearranged parts of the original papers so that with his own additions assimilation is easier. Anyone currently considering whether research reactors can be of use in his particular field would do well to study this book as a guide to what can be done.

Part 1 is bound to attract most interest, and unless the reader is directly concerned with choosing a particular type of reactor or for some other reason concerned with comparing details of the different types, Part 2 may prove a rather long catalogue. However, the number of people with such interests is increasing in both industry and the universities, and to them the book should be more easily read than the alternative sources referred to.

F. W. FENNING

Medical Radiation Biology

By Friedrich Ellinger. Pp. xxxiv+945. (Springfield, Ill.: Charles C. Thomas; Oxford: Blackwell Scientific Publications, Ltd., 1957.) 150s.

THIS is a book written by a physician for physicians and as such it should prove a useful textbook for radiotherapists and a valuable reference book for medical men whose contact with radiation problems is more intermittent.

The book is written almost in lecture-note form. It is strictly systematic and exhaustive, with very adequate cross references. This, together with the 5,000 references, makes it a very valuable information source for all workers in radiobiology. It will not, however, rank as a scientific treatise on radiobiology, for the treatment is rather elementary and didactic. The early chapters on the fundamental aspects of radiation and radiation effects are rather unsatisfactory and some would consider them occasionally misleading. For example, the early statement that it is possible to consider all the effects of radiation under a single biological concept as a 'stimulus' would scarcely appeal to the physiologist.

The greater part of the book is concerned with a detailed description of the effects of radiation on the various tissues and organs of the body in health, disease and malignancy. The effect of externally administered X- and γ-radiation is, of course, the main theme, but the effects of ultra-violet and visible light are also fully dealt with. There is also a valuable section on the effects of radiations arising internally from administered isotopes. Health hazards are kept to the fore and discussed at appropriate points throughout the text.

Glossary of Indian Medicinal Plants

By R. N. Chopra, S. L. Nayar, and I. C. Chopra. Pp. xx+330. (New Delhi: Council of Scientific and Industrial Research, 1956.) Rs. 8.

THE object of this glossary is to present a concise record of the information regarding the properties and uses of the medicinal plants of India as a guide to those interested in indigenous drugs.

Much of the information is a result of an all-India survey of medicinal and poisonous plants, visits to centres of learning of indigenous medicine and consulting the literature on local herbaria and libraries.

The plants have been arranged in alphabetical order according to their scientific names, so that there will be no difficulty for readers in finding any particular drug. Many of the commonly used

synonyms have been inserted as cross-references to their modern scientific names. Abbreviations have been used in order to compress data into a small handy volume and a list of these has been included for ready reference. When a number of plants belonging to the same genus is discussed, the name of the family to which the plants belong is supplied with the scientific name of the genus. Important vernacular names commonly used in different regions of India have been given, and an index of these names has been provided at the end. The diseases for which the particular plant is used are also briefly described.

A special feature, which will not fail to attract attention, is the inclusion of brief accounts of the active principles of plants so far as they have been worked out. An index of chemical constituents is provided. Under the name of each plant, there are abundant references to scientific journals and books.

S. B. CHALLEN

Cloud Study

A Pictorial Guide. By F. H. Ludlam and Dr. R. S. Scorer. Pp. 80. (London: John Murray (Publishers), Ltd., 1957.) 12*s*. 6*d*. net.

THE basis of this book is a selection, preceded and accompanied by explanatory text, of seventy-three photographs with a frontispiece in colour, from the fine collection of the Royal Meteorological Society, the files of its monthly magazine *Weather* and other sources, including the private collections of the authors themselves who have added much to our knowledge of clouds. All the familiar types of cloud are well represented, but possibly the most commanding picture shows the stupendous wall of cumulo-nimbus cloud surrounding the clear 'eye' of a Western Pacific typhoon. From this, one can well believe the statement that a tropical cyclone is an "organized system of cumulo-nimbus clouds". A useful inclusion for purposes of identification is the photograph of the seldom seen but peculiarly beautiful cirriform noctilucent clouds probably consisting of small dust particles instead of water droplets. These form high up in the stratosphere at altitudes of about 80 km. and may be seen in the higher northern latitudes on summer nights between May and August. The authors explain very clearly the fairly well-known physical transformation of large cumulus clouds into showery cumulo-nimbus. Yet one feels there is more to learn about the great cumulus clouds. What is the critical factor which gives them their sharp outlines and rock-like solidity of aspect notably when piled on the horizon like a mighty range of mountains? Ruskin used to expatiate upon this a hundred years ago.

L. C. W. BONACINA

The Physics and Chemistry of Life

(A *Scientific American* Book.) Pp. xi+270. (London: G. Bell and Sons, Ltd., 1957.) 13*s*. 6*d*. net.

THESE eighteen short essays first appeared in the magazine *Scientific American*. The book begins with a discussion of the origin of life and ends with an article on the electrical activity of the brain. Most of the writers are recognized leaders in the field of work which they have chosen to describe. The subjects include photosynthesis, nitrogen fixation, the structure of proteins in general and of insulin in particular, the nature of genes, enzymes, viruses and nucleic acids, the mechanisms of cell division and differentiation, and the properties of muscle and nerve. The standard of 'popularity' varies a good deal from one essay to another. Some of the authors have assumed that their readers will have an elementary knowledge of organic chemistry; others might have been wiser to have made this assumption: for example, it is not easy to give a clear account of the modern view of fatty acid oxidation without using any structural formulæ.

The article by G. Beadle on the genes of moulds and man shows the way in which the study of the bread mould *Neurospora crassa* has helped to explain how genes act. It may perhaps be selected as an example of popular scientific writing at its best.

Taken as a whole, these essays give a broad picture of some of the more exciting topics of present-day biological research. Considering the very reasonable price of the book it would perhaps be ungenerous to complain of the poor standard of production of some of the diagrams.

D. C. HARRISON

Tables of the Non-Central *t*-Distribution

Density Function, Cumulative Distribution Function, and Percentage Points. By George J. Resnikoff and Gerald J. Leiberman. (Stanford Studies in Mathematics and Statistics, Vol. 1.) Pp. x+389. (Stanford, Calif.: Stanford University Press; London: Oxford University Press, 1957.) 100*s*. net.

THE quantity known as 'Student's t' is widely used in statistics to test the significance of a mean; it is, in effect, the ratio z/s, where z is a normal variable with zero mean and unit standard deviation and s^2 is an independent variance estimator distributed as χ^2/ν with ν degrees of freedom. The quantity called 'non-central' t is the quantity $(z + \delta)/s$, where δ is some given constant. Its distribution requires tabulation by triple entry, according to t, ν and δ. Originally, it was required for the power function of tests based on 'Student's t', but more recently has found application in a number of other fields.

These tables present the frequency, the distribution function and the percentage points of non-central t to four decimal places for $\nu = (1)24(5)49$; with standardized argument $t/\sqrt{\nu}$; and for values of δ determined as $\sqrt{(\nu + 1)}K_p$, where K_p is a standardized random normal deviate with probability integral $1 - p$. The tables were computed on an IBM card programmed computer and are legibly reproduced from photographed typescript. Statisticians will be grateful to the authors and to the Stanford University Press for making this work, which was done under a Naval research contract, available for general use.

Modern Computing Methods

Department of Scientific and Industrial Research: National Physical Laboratory. Notes on Applied Science, No. 16. Pp. vi+129. (London: H.M. Stationery Office, 1957.) 10*s*. 6*d*. net.

THIS work is based on lectures delivered by various members of the staff of the Mathematics Division of the Laboratory during a vacation course on "Computers for Electrical Engineering Problems". It gives a brief account of those computing methods which are likely to be of general use, and its emphasis is essentially practical. There are twelve chapters, the first four of which deal with algebraic problems including the determination of the real and complex roots of polynomial equations, the inversion of matrices and the determination of their latent roots and vectors, and the solution of simultaneous linear algebraic equations. Chapter 5 introduces the theory of finite differences which is used in the following two

chapters to solve ordinary differential equations of the boundary-value and initial-value types. Chapter 8 is mainly concerned with quasi-linear partial differential equations of the second order in two independent variables and uses the method of 'characteristics' for the solution of the hyperbolic equations. The treatment of the elliptic and parabolic partial differential equations is given in Chapter 9, and relaxation methods are discussed in Chapter 10. The last two chapters discuss the various problems which arise in the computation, construction, checking and presentation of numerical tables of mathematical functions. The account is necessarily condensed, but it is supplemented by an extensive and most useful bibliography of reasonably accessible literature. S. Weintroub

The Physiology and Biochemistry of Lactation

By Dr. S. J. Folley. Pp. viii+153+19 plates. (Edinburgh and London: Oliver and Boyd, Ltd., 1956.) 18*s*. 6*d*. net.

In the past twenty years the Physiology Department of the National Institute for Research in Dairying, under the leadership of Dr. S. J. Folley, has made outstanding contributions to knowledge of the biochemistry and physiology of lactation. The present book is based on a series of lectures given by Dr. Folley at the Collège de France. It presents a commendably clear and readable account of the important advances that he and others have made in the subject, and adequately describes modern methods by which these advances have been achieved. The first of the six chapters discusses the growth of mammary tissue and how it is influenced by œstrogen, progesterone and some of the anterior pituitary hormones. The second and third chapters deal with the initiation and maintenance of lactation, and the fourth with the milk ejection reflex, the nature of the milk ejection hormone and the effector contractile tissue of the mammary gland. The last two chapters describe modern views on the methods by which milk fat, lactose and milk proteins are formed in the gland. The book is well illustrated, the figures and tables are clear and concise, and a valuable list of references accompanies each chapter. It is a book that can be highly recommended to students, lecturers and research workers and indeed to all whose job it is to understand the functioning of the actively secreting mammary gland. J. A. B. Smith

The Armored Scale Insects of California

By Howard L. McKenzie. (Bulletin of the California Insect Survey, Vol. 5.) Pp. v+209+3 plates. (Berkeley and Los Angeles: University of California Press; London: Cambridge University Press, 1956.) 45*s*. net.

The wide range of species of the armoured scales, or Diaspididae, to be found in California include many that are primary pests of major agricultural crops. The object of the present work is to enable the thousands of specimens received annually by the State Department of Agriculture to be accurately identified and their occurrence within the State recorded, so that the economic importance of the species may be evaluated. The book, by a well-known authority on this group of insects, is admirably designed to meet this objective.

Keys to genera and species are given as well as excellent detailed figures of each species. The species are not described but the more important taxonomic references are listed and can be consulted where the identity is in doubt. Excellent colour photographs of some of the more important species are included; but it is open to question whether these are of any great aid to recognition, as closely allied forms are often so very much alike in appearance. Type locality and host as well as other known hosts are given for each species as well as other useful information. There are an index to the genera and species, a host index and a host list including the Diaspidid species, arranged alphabetically under plant families.

This book is very well arranged and brings together a wealth of information that will be invaluable to workers in California. But although it deals with the fauna of a restricted area, many of the species have a very much wider distribution, not only in North America but also throughout the world. It will therefore be of considerable value to all those interested in this group of insects of considerable economic importance. W. J. Hall

Rocket Propulsion Elements

An Introduction to the Engineering of Rockets. By George P. Sutton. Second edition. Pp. xii+483. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1956.) 82*s*. net.

It is surprising that in spite of the growing importance of rockets since the Second World War so few books have been written dealing with rocket propulsion from the point of view of the design and development engineer. When first published in 1949, this book was the only one of its kind and even to-day it has no equal. This second edition brings the subject up to date and remedies some of the weaknesses of the first edition. The book has been enlarged by approximately 60 per cent and includes new material on both liquid- and solid-propellent motors, the subject-matter of the latter in particular being a considerable improvement on the first edition. A more comprehensive treatment of heat transfer is also included, although radiation could have been dealt with more fully. The many worked examples and the problems at the end of each chapter are useful features although the student would appreciate answers to more of the problems. In a book of this nature covering such a wide field it is inevitable that certain aspects of rocket propulsion cannot be dealt with as fully as some people would wish, and so for those wishing to delve more deeply into specialist subjects there is a greatly enlarged and well-arranged bibliography at the end of the book.

This is a comprehensive technical book covering both the theory and practice of rocket engines and can be thoroughly recommended to all those, whether students or practising engineers, who are concerned with rocket propulsion.

Through Alchemy to Chemistry

A Procession of Ideas and Personalities. By Prof. J. Read. Pp. xvii+206. (London: G. Bell and Sons, Ltd., 1957.) 18*s*. 6*d*. net.

Those who have an acquaintance with Prof. Read's earlier books, "Prelude to Chemistry" (1936), "The Alchemist in Life, Literature and Art" (1947), and "Humour and Humanism in Chemistry" (1947), will know how ably and with what charm of style he can draw on his fund of specialized knowledge of the chemistry of the past and the personalities of its practitioners. A new book by him in this field may be expected to be good, and this latest one from his pen amply fulfils expectations.

It is, as he says, in some way a digest of the earlier works, to which material from his "Direct Entry to Organic Chemistry" (1949), which was awarded the Cortina-European Prize of a million lire, has been added. The text takes the reader from the ideas of the earliest civilizations through the long period of alchemy to modern times, the age of the benzene ring, electrons, atomic structure, and chemistry in space. The illustrations, including many excellent plates, add interest and understanding to the story; many of them would be difficult to find elsewhere. The book is designed to be intelligible to the educated reader not familiar with the details of chemistry; the only chemical equation in it is $2H_2 + O_2 = 2H_2O$, and anyone who knows the full history of all that lies hidden in this simple expression will have an idea of what could be expounded from such familiar things.

Prof. Read's book can be warmly recommended to all who care for the better things of science; to the chemist, to the young reader who will be attracted by its clarity and interest, to the historian, and to the many who are now aware that the history of science is not only of value in itself but also forms an integral, although sometimes neglected, part of the whole history of civilization.

J. R. PARTINGTON

A Practical Guide to Plant Sociology for Foresters and Agriculturists

By Prof. F. R. Bharucha and Dr. W. C. DeLeeuw. Pp. viii+44. (Bombay; Calcutta; Madras: Orient Longmans Private, Ltd., 1957.) Rs. 5.

WITH the revival of the Botanical Survey of India, the authors have brought out this little book to provide, in easily available form, some tangible suggestions for methods of studying the ecology of Indian vegetation. They have, in fact, outlined the methods of the Zurich–Montpellier school of phytosociology. The difficult task of doing this within the space of forty pages has been well tackled, but it seems questionable whether the emphasis on brevity has not been too great. One cannot help feeling that the inexperienced ecologist, when he comes to use the book for practical field studies, is likely to be left a prey to unsolved doubts as to just how he should begin. Nevertheless, the book does put into his hands useful data on the Zurich–Montpellier techniques, which, with some general guidance, should enable him to contribute towards a systematic description of Indian vegetation.

The book can also serve to give botanists who are unfamiliar with the work of the Zurich–Montpellier school a nodding acquaintance with its methods. That many British ecologists are critical of these methods is irrelevant here, but the widespread lack of understanding between the two schools of thought might be lessened by a better knowledge on both sides.

MAURICE ASHBY

Plastic Design of Portal Frames

By Dr. Jacques Heyman. (Cambridge Engineering Series.) Pp. viii+104. (Cambridge: At the University Press, 1957.) 10*s.* 6*d.* net.

QUITE apart from the interest of its subject, Dr. Heyman's book is attractive because of two features not usually encountered in modern technical publications. First, it is inexpensive, and secondly, it does not pretend to be a fully-exhaustive treatise on a wide field. The text deals with single-story portal-framed buildings only, and does not stray outside the terms of reference so set.

It is worth noting that the conception of the steel frame as part of a finished structure is constantly kept before the reader. He is not given the theoretical background only, and left to apply this to design as well as he can; throughout, the emphasis is on completing the task of translating the ideas developed at Cambridge into the completed building.

Dr. Heyman has the valuable faculty of realizing that the student of his subject may well find difficulties even in the elementary stages. He makes a considerable effort to ensure that the simplest application of plastic design—to continuous beams and purlins—is thoroughly understood, and then builds logically and gradually on this basic understanding until such complex frames as multi-bay portals and tied portals under wind loading are being considered.

The book achieves its purpose of introducing the newcomer to this powerful British method of steel design, but Dr. Heyman realizes the limitations of his space and has confined himself to a type of structure where strength of sections rather than stiffness of stanchions is likely to be the controlling factor. Those readers interested in instability or multi-story construction must turn to the excellent bibliography for further direction.

W. FISHER CASSIE

Trilinear Chart of Nuclides

By William H. Sullivan. Pp. ii+4+chart. (Washington, D.C.: Government Printing Office, 1957.) 2 dollars.

W. H. SULLIVAN'S "Trilinear Chart of Nuclides" has just appeared in its second edition. One can surely say without exaggeration that every nuclear physicist and chemist, and, in addition, the large group of people who require nuclear data in their work, will be delighted to be able to embellish the walls of their offices or laboratories with this very useful atlas of nuclides or, at least, have it handy for ready reference in their desks.

I am sorry to find that the colour scheme of the first edition has been replaced by printing the hexagons in heavier or lighter print for the naturally occurring isotopes and the artificial ones. Even with the advantage of a lower price for the chart, the sacrifice of beauty seems regrettable.

The organization of the new chart is identical with that of the first edition. The amount of information presented is very large, and great pains seem to have been taken to ensure accuracy. At a price of 2 dollars the chart should be extremely popular with the scientific world.

E. BRETSCHER

Complexometric Titrations

By Prof. Gerold Schwarzenbach. Translated and revised in collaboration with the author by Dr. Harry Irving. Pp. xviii+132. (London: Methuen and Co., Ltd.; New York: Interscience Publishers, Inc., 1957.) 21*s.* net.

MOST chemists are familiar with at least a few of these elegant methods, but all will welcome this survey and be surprised at the variety and extent of the applications. More than 300 references are given to papers, nearly all of which have appeared in the past decade or so.

Prof. Schwarzenbach, the pioneer of complexometric titrations, gives a very clear discussion, aided

by numerous neat diagrams, of the theory underlying the stability of the complexes and the titrations. The use of dyes as metal-indicators arose from a chance observation made when hard tap-water containing calcium was being employed for washing vessels in which a complexone and murexide had been used. (The chance observation would probably have been wasted had it not been made by the eye of a genius.) The indicators are so sensitive that end-points are very sharp even with 0·01 *M*-titrants.

The use of masking agents, enabling mixtures to be titrated, is fully explained, as is also the preparation of the necessary *p*H buffer solutions. Nearly forty detailed determinations include examples of direct, indirect, substitution, and back titration and suggest many further applications.

This 'translation' is much more than the dry bones often covered by that term, for Dr. Irving has been associated with the author in the preparation of a second German edition and has not hesitated to make such alterations as seemed desirable. There are a few misprints, and some of these are important.

The publishers are to be congratulated on the production of a well-printed and well-bound book at a reasonable price. A. D. Mitchell

Biological Staining Methods

By George T. Gurr. Sixth edition. Pp. vi+102. (London: George T. Gurr, Ltd., 1957.) 5*s*.

The diversity of staining techniques has increased so greatly in recent years that it is often difficult for the non-specialist to choose those most applicable to his problem. A book of this type, which presents clearly a wide selection of methods, is thus of great value, not only to students but also to all who use staining methods. This new edition of Mr. G. T. Gurr's book follows the plan of previous issues, devoting sections to bacteriological, hæmatological and general methods. Some new techniques have been added, together with a section on fluorescence microscopy, a method which is of increasing importance in biological research. A most useful feature of the book is the expanded formulary, giving the composition of many staining solutions, and also the appendix which lists the solubilities in water and in alcohol of many common chemicals and stains. A possible improvement which might be incorporated in any later edition would be the separation of the histochemical methods from the general stains and their expansion into a separate section. This, however, is a minor criticism, and the book in its present form will, I feel, prove a most useful reference work, particularly to students and laboratory technicians.

S. Bradbury

Metrology and Gauging

By S. A. J. Parsons. Pp. xxii+286. (London: Macdonald and Evans, Ltd., 1957.) 25*s*.

The ever-present demand for greater precision in manufactured articles has created the need for a wider knowledge of metrological techniques among those engaged in production processes, not least the designer himself. It is becoming increasingly recognized that instruction in this subject should form part of the curriculum of the engineering student, and the book under review has been particularly designed to cover the syllabus requirements of examinations leading to corporate membership of the Institution of Mechanical Engineers and the Institution of Production Engineers, and similar examinations. However, the author's treatment of the subject makes the book equally valuable to the practising engineer.

An introductory chapter deals with the fundamental standards of length, and this is followed by a description of the use of light-waves as length standards and various forms of interferometer embodying this principle.

After a chapter on the interchangeability of components, the author discusses in considerable detail the design, manufacture and testing of limit gauges. This is followed by several chapters on commercially available measuring instruments, which have been grouped according to their principle of operation, namely, optical, mechanical, electrical or pneumatic. The application of these instruments to screw thread measurement and the testing of straightness, flatness and alignment follows. Two chapters are devoted to the measurement of gears and surface finish. The appendixes include a list of relevant British Standards and some typical examination questions.

This book, having regard to its purpose, quite adequately introduces the subject of metrology, and clearly indicates present trends in measuring techniques. However, the author's presentation of his material could have been improved by re-grouping it in a more logical sequence, and the list of chapter contents could with benefit be shortened. The illustrations are plentiful, and a clear fount makes the book pleasant to read. P. W. Harrison

The Rolling of Strip, Sheet and Plate

By Eustace C. Larke. Pp. xi+404. (London: Chapman and Hall, Ltd., 1957.) 63*s*. net.

In this book a remarkable amount of material has been compressed into one volume. The opening chapter deals with modern rolling plant. Then a chapter on multi-roll mills describes the fascinating Sendzimir mill and its advantages. There follow chapters on roll cambers, gauge variation of rolled strip, rolling loads and rolling schedules. Numerical and graphical methods for computing the latter are fully described in simple terms, and nowhere is the text so condensed that the reading becomes difficult. A whole chapter is given to the influence of coiler and decoiler tension on the rolling load. Then come chapters on deformation, hot rolling and the calculation of hot-rolling loads. Finally, there are chapters on the energy consumed in cold and hot rolling and on the productive capacity of strip mills. This last chapter presents practical methods for calculating the capacity, and effects considered include handling time, waiting time, length and weight of coils and rolling speed.

A considerable part of the book is devoted to methods of calculation, and it may not be out of place to make two comments. The amount of *ad hoc* approximation made in order to simplify complex mathematical equations might be largely avoided by using an electronic computer to solve some of the design problems; and, for complicated situations where the validity of the assumptions leading to the theory are in doubt, there may be something to be gained by using statistical design in experimentation. For example, improvement in the use of existing productive plant may be sought by the use of the Box technique of evolutionary operation.

It is to be hoped that the book will be of interest to mill managers and their technical staff as well as students. L. S. Goddard

Peculiar Disorder of Plasma Thromboplastin Production

ONE of the several functions of platelets is participation in the formation of plasma thromboplastin. Recently, we encountered in the blood of a patient an agent with the unprecedented action of specifically hindering this activity. Thus, the presence of his plasma or serum in the incubation mixture inhibited the generation of plasma thromboplastin[1]. Compared with a normal control (Table 1) the derangement, as estimated from the clotting time of the substrate, was more apparent on reducing the number of platelets (experiments *B* and *C*) and practically abolished on using a concentrated suspension (experiment *D*).

Table 1. EFFECT OF PLATELET CONCENTRATION ON INHIBITOR ACTIVITY

Experiment No.	Platelet suspension (10^3/mm.^{3})	Clotting time of substrate (sec.)* Source of plasma or serum	
		Normal	Patient†
A	600	10	14
B	300	12	19
C	150	14	25
D	1,200	8½	9

* Equal volumes of plasma treated with aluminium hydroxide (1 : 5), diluted 1 : 10 serum, platelet suspension and 0·025 *M* calcium chloride were incubated at 37° C. for 6 min. The activity of the mixture was tested by taking 0·1 ml. together with 0·1 ml. 0·025 *M* calcium chloride and adding them simultaneously to 0·1 ml. normal citrated plasma (substrate), and recording the clotting time.

† In this case the incubation mixture contained either patient's plasma and normal serum or patient's serum and normal plasma.

Antihæmophilic globulin and Christmas factor levels[2] were determined in the presence of excess platelets; normal results were obtained. The patient's platelets were fully active in the thromboplastin generation test. Pre-incubation of normal platelets with patient's plasma or serum did not cause further deterioration in the production of plasma thromboplastin, indicating that the inhibitor has a retarding but not a destructive action on the platelet thromboplastin component. Further study has shown that this inhibitor counteracts the combination of platelets with antihæmophilic globulin and Christmas factor; the activity of other blood-clotting factors or their intermediate products were uninfluenced.

F. NOUR-ELDIN*
JOHN F. WILKINSON

Department of Hæmatology,
Royal Infirmary,
Manchester 13.
Nov. 4.

* Research Fellow in Hæmophilia.

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Salt Intake, Adrenocortical Function and Hypertension

A RECENT communication[1] proposed that the high levels of salt consumption current in modern societies were beneficial since the salt stimulated adrenal cortical function and thereby set in motion various adaptive mechanisms that make the individual more responsive to the stresses of modern living. Space does not permit examination of whether modern living actually has more stresses than a primitive life: one American anthropologist, Prof. G. P. Murdock of Yale University, several years ago[2] expressed strong doubts that such was the case.

Although the addition of salt to food is as old as recorded history, many vigorous groups have used none except that which occurred naturally in foodstuffs; for example, Eskimos, certain of the Chinese and North American Indians, the Lapps, and the Masai of Africa. Available data indicate that the sodium intake on these natural diets would range from about 1 to 2 gm. (2·5–5 gm. as sodium chloride) and sometimes less. Beginning with the pioneering work of Allen[3], drastic salt restriction has been used widely in the treatment of various diseases. During the past ten years I have studied some 75 patients in metabolic wards for long periods before and after sodium restriction of 40–175 mgm./day. These people have maintained sodium balance and normal activity, and evidence of impaired adrenocortical function has not been observed. One walking hospital patient has now been restricted to about 115 mgm. sodium/day for more than four years; she remains in electrolyte balance, and numerous clinical and biochemical tests of adrenocortical function, including the response to intravenous adrenocorticotrophic hormone[4], which were made recently, indicated a normally reactive adrenal cortex. In other patients, psychiatric interviews, psychometric studies and electroencephalograms before and after drastic salt limitation revealed no changes. It has been concluded that adrenocortical function is normal on a low salt diet.

Finally, is a high salt (sodium chloride) diet itself disease-producing? I believe there is ample evidence to indicate that salt is a primary cause of 'essential' hypertension which, after atherosclerosis, is the commonest form of cardiovascular disease in Western society. For some years, I have been intrigued by the apparent low incidence of hypertension among many primitive races; it was of interest to find that among such groups for which data were available, a low dietary intake of sodium was a common factor, generally 1–2 gm. per day. (All experimental and clinical evidence indicates that it is the sodium, not the chloride ion, which is toxic.) Up to the present time I have found no reports of groups which habitually consume low sodium diets and have hypertension to any significant degree.

It has been known for several years that feeding salt to rats will produce a disease which mimics human hypertension[5]. Beginning in 1954, I have published evidence indicating that individuals customarily on a high salt diet will have significantly more hypertension than those on a low salt diet[2,6]. It is known that the West Indian Negro has a much greater incidence of hypertension than the Whites in the same area[7], and according to Prof. Murdock the evidence suggests that from early childhood the Negroes eat a diet high in salted pork and fish. The Southern Negroes of the United States have several times as much hypertension as the Southern Whites[8]. My interviews with Negroes from that region indicate that for most of them salted pork in one form or another has been a prominent article in the diet from early childhood.

Prof. A. Halawani, director-general of the Research Institute of Tropical Medicine, Cairo, informed me last year that the Egyptian peasants ordinarily ate large amounts of heavily salted cheese, and when available, salted fish: he had no precise statistics, but it was his impression that hypertension was relatively common among these peasants in contrast to most Africans and Orientals[6].

It has been axiomatic that Orientals have little or no hypertension[6]. From the work of Prof. T. Fukuda,

Physiology Department, Chiba University, Japan[9], and a Japanese Government bulletin[10], the following data emerge: (1) hypertension is a widely prevalent and serious disease in Japan; (2) fatal cerebral apoplexy is the commonest cause of death and is 1·5–2·0 times more frequent than in the United States; (3) in the Prefecture of Akita, where hypertensive cardiovascular disease is especially common, the daily sodium chloride intake (based on 24-hr. urinary chloride excretion of 268 adults) averaged 26·3 gm.—about twice the average Japanese intake, and 2·5 times the average intake of the American male[11]; (4) among 2,082 unselected men studied in Akita the following blood-pressure data were found: at ages 20–40, about a quarter had systolic pressures greater than 140 mm. mercury and a fifth had diastolic pressures of 90 mm. mercury or more; at ages 40–60, 35–62 per cent had systolic elevation and 37–50 per cent had diastolic elevation in excess of 140 and 90 mm. mercury, respectively. A similar incidence of elevated blood pressures was found in the 3,219 women who were examined. At corresponding ages this frequency of elevated blood pressures is about twice that of the Japanese population as a whole and is in striking contrast with areas in China and India where low salt diets are the rule and hypertension is a rare or an uncommon disease. I do not know of other areas in which such a high incidence of elevated blood pressure is present, although they presumably exist.

From the foregoing, the following conclusions seem justified: (1) a low salt diet is associated with normal adrenocortical function; (2) a high salt diet is associated with a markedly increased incidence of hypertension and cerebral apoplexy; (3) evidence discussed elsewhere[2 4c] suggests that the high salt intake is a cause of, and not caused by, the hypertension; (4) sharp reduction of current levels of salt intake could be carried out without harm and probably with great benefit, by reducing the incidence of hypertensive cardiovascular disease. Furthermore, I predict that wherever low salt diets prevail (that is, less than about 2 gm. of sodium per day) hypertensive cardiovascular disease will be uncommon; conversely, where high salt diets (that is, more than perhaps 5 gm. of sodium per day) are the rule, hypertension and its complications will be frequent.

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Lewis K. Dahl

Brookhaven National Laboratory,
Associated Universities, Inc.,
Upton,
Long Island, N.Y.
Jan. 13.

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Intestinal Carcinoma in Mice following Injection of Herring-Sperm Deoxyribonucleic Acid

The transmission of genetical characteristics from one strain of bacteria to another by means of deoxyribonucleic acid is now well recognized. However, apart from the claim by Benoit *et al.*[1] to have altered the hereditable features of certain ducks, the method does not appear to have been applied clearly and successfully to the higher organisms. Nevertheless, it seems theoretically possible, by analogy with the achievements in bacterial transformation, that some characteristics of cancer cells might be transmitted to normal cells by means of tumour deoxyribonucleic acid, and experiments are being carried out here with that end in view.

It was felt that adequate controls should reasonably include not only the parallel administration of normal deoxyribonucleic acid of the same species and strain and preferably of the same tissue as that from which the tumour was derived, but also that of an entirely foreign species which might reveal non-specific effects on cell metabolism. From bacteriological evidence it seemed that direct interaction between the deoxyribonucleic acid of the host and that newly introduced might occur only if the new acid were highly polymerized and derived from a source showing close genetical relationship.

Experiments were carried out on young line-bred *C3H* mice, and the foreign deoxyribonucleic acid chosen was a commercial preparation of herring sperm. In the course of investigations, two three-weeks old females of a litter of four received five daily injections of the deoxyribonucleic acid of herring-sperm. On the twenty-third day after the first injection, one died and the other, being moribund, was killed. Both bore a solid whitish tumour mass involving duodenum, jejunum and mesentery, together with small deposits scattered over the peritoneum and in adjacent lymph nodes. A considerable amount of blood-stained ascitic fluid containing numerous tumour cells was present, and the general picture was similar in both cases.

Histological examination showed an adenocarcinoma arising in the mucosa of the duodenum. In some areas there was tubular differentiation, but elsewhere the tumour was undifferentiated. The solid tumour has been passaged with difficulty to other *C3H* mice but not to other strains. The ascites cells have been transmitted to both *C3H* and albino mice (laboratory strain), resulting in the growth of both solid and ascites forms, with some animals dying as early as six days after injection as a result of tumour proliferation.

The two litter mates (females) which received no treatment have remained healthy, and we have as yet found no reference to such a tumour developing spontaneously in mice of any strain. It is true that we have not so far been able to repeat this result; but in our view the development of a tumour so unusual in its site of origin and in its behaviour in young mice in these circumstances cannot be disregarded. This *C3H* strain of mice has, of course, a high incidence of spontaneous mammary carcinoma transmitted by the Bittner milk factor, which develops normally in adult females. We think it most unlikely that the foreign deoxyribonucleic acid was incorporated into the nuclei of the mouse tumour, but it may well owe its carcinogenic effect to an interference with the synthesis of a normal acid in

the cells of the duodenal mucosa, which is developing extremely rapidly at this stage.

If we had achieved this result by using deoxyribonucleic acid derived from a mouse tumour we should have been tempted to suppose that the abnormal acid had been assimilated in the genetical material of the mucosal cells in the manner of bacterial transformations. The production of a tumour in this control group indicates the need for extreme caution in interpreting positive results in work of this kind.

T. F. Hewer
E. S. Meek

Department of Pathology,
University of Bristol. Jan. 18.

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Mast Cells

Influence of Cobalt on White Mouse Skin Mast Cells

Observations on the action of cobalt compounds on living organisms revealed that this is to some extent similar to that of histamine. Therefore, as mast cells may produce and/or store histamine and histamine-like substances attached to heparin molecules, it was of interest to see if the cells examined were influenced by cobalt compounds. These were given intraperitoneally to white mice in a single dose of 100 mgm. cobalt/kgm. body-weight, in the form of cobalt nitrate, acetate and chloride. Another series of mice received 5 mgm. cobalt/kgm. in the same salts daily for 3 weeks. Specimens of the skin were fixed and stained by a modified Nowak and Zahl stain[1].

Within 1–1½ hr. of receiving a single dose of any of the cobalt compounds an enlargement of the granula and an increase of their metachromasy were observed. The nuclei of the cells were enlarged, and amitotic cell divisions that occurred during full secretion activity of the mast cells were seen frequently, after which the cells were destroyed by clasmatosis. The metachromatic granula then lay in the substantia fundamentalis for more than 5 hr. The separate nuclei underwent pycnosis, and after clasmatosis occurred there was no way of measuring them.

In white mice receiving only 5 mgm. cobalt/kgm. the increased activity observed in the above experiments is much less. After receiving cobalt compounds for 23 days the cells described are found fairly frequently in the specimens, almost all being disrupted, with their granulations often orthochromatically stained. They remain in the proximity of the intact cells forming crown-like structures.

When the same concentration of the cationic components of the cobalt compounds were used the results were similar.

From the experiments described above it follows that cobalt may stimulate the activity of the mast cells, cause their disruption and finally their degeneration. It also stimulates mitosis within the range of doses used and in this way may liberate the substances produced by these cells.

Diurnal Variations of the Mast Cell Activity

Work over several years has revealed that mast cells secrete heparin and/or histamine[2,3]. We wished to determine whether there are significant morphological variations of the mast cell activity, similar to those described in other organs examined for 24 hr. The observations were made on white mouse skin at 3 hr. intervals for 27 hr. The specimens were stained by a modified Nowak and Zahl method[1]. The kariometric analysis revealed that a definite rhythm exists in the activity of these cells. Detailed data are given in Table 1. The cytoplasmic granula of the cells are most delicate during the morning, at 6 and 9 a.m. The maturity, that is, the extent of metachromatic staining, is also minimal at these times. The metachromasy of cell granula increases towards the night and reaches a maximum at midnight. Clasmatosis during the day is minimal and increases during the night.

Table 1. Mean Diameters of the Nuclei of Skin Mast Cells during 24 hr.

Hr.	Percentage of nuclei with a diameter (μ)								
	2·4	3·6	4·8	6·0	7·2	8·4	9·6	10·8	12·0
3	0	4	13	47	21	8	5	2	0
6	2	10	37	21	16	9	5	0	0
9	5	11	31	38	10	5	0	0	0
12	1	7	18	43	21	6	4	0	0
15	0	2	9	31	39	14	3	2	0
18	0	1	2	6	22	27	20	17	5
21	0	0	4	15	31	38	10	2	0
24	0	0	6	23	36	19	9	7	0

The results show that mast cells, as probably all cells of living organisms, are influenced by day and night changes. This fact is of interest not only in the examination of the fate of heparin and histamine in the organism, for the diurnal factor must be taken into account as a very significant one in any observations on labrocytes, that is, on mast cells.

Tadeus Niebroj

Dept. of Histology,
Silesian Medical School,
Zabrze, Poland. Jan. 7.

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A Lipopolysaccharide Antigen of the *Treponema*

Immunochemical studies carried out by D'Alessandro *et al.*[1] on a non-pathogenic, culturable treponeme, the so-called Reiter treponeme, revealed the presence of four antigenic components: (1) a thermolabile protein; (2) a specific, thermostable antigen with polysaccharide characteristics; (3) a lipoid, corresponding to the ubiquitous lipidic antigen cardiolipin; (4) another lipoid similar to the organ-specific cerebral antigen of Witebsky[2]. These studies led to the conclusion that the treponemes, like other organisms, are mosaics of antigens, and a safe basis was established for a better understanding of the complex serological response of the infected host.

In the serodiagnostic field the interest has been focused so far on the Reiter protein antigen, which proved to be a valuable antigen in syphilis serology. The reactivity of the protein antigen, which shows a remarkable specificity and sensitivity, in the complement fixation test with syphilitic serums, is understandable on the assumption that a common antigenic component exists in the Reiter and in the pathogenic *Treponema pallidum*, as indicated by experiments of Dardanoni and Censuales[3].

From the investigations carried out in 1949, the polysaccharide antigen of the Reiter treponeme appeared to be of minor interest from the sero-

diagnostic point of view. The antigen isolated from the treponemes by trichloracetic extraction of organisms treated with sodium hydroxide, behaved as a haptene: it failed to elicit antibodies in the rabbit and its *in vitro* reactivity with syphilis serums was sparse and weak. These results discouraged further investigations.

However, bacterial polysaccharide or lipopolysaccharide antigens are generally considered to be outstanding components of the organisms in relation to their immunogenicity and *in vitro* reactivity. With this in mind, the problem of the polysaccharide treponemal antigen has been re-investigated in this laboratory. This led to the preparation of a lipopolysaccharide antigen which appears to be clearly reactive in the complement fixation test with syphilitic serums.

Reiter organisms grown in Brewer thioglycholate medium are centrifuged and treated with sodium deoxycholate[4]. Enough 40 per cent trichloracetic acid solution is added to the viscous fluid resulting from the deoxycholate treatment of treponemes to give a final concentration of 5 per cent. The mixture is then kept at 4° C. for 4 hr. After centrifugation the supernate is harvested, the trichloracetic acid removed by dialysis and 4–5 volumes of ethanol added. In a few hours a precipitate is obtained which is centrifuged, redissolved in water and again precipitated. This procedure is repeated three times. The antigen is finally dissolved in water and lyophilized. For use, 1 mgm. of the lyophilized preparation is dissolved in 1 ml. of saline, giving an opalescent solution without sedimentable turbidity.

The antigen inoculated intravenously in rabbits produces antiserums which react definitely with homologous antigen in the complement fixation test; heterologous lipopolysaccharide antigens derived from some Gram-negative enteric organisms did not react with such serums. The Reiter lipopolysaccharide antiserums give a positive complement fixation test with suspension of intact Reiter organisms; similarly, Reiter organism antiserums react with the lipopolysaccharide antigen. Serums obtained from rabbits experimentally infected with Nichols strain of pathogenic *Treponema pallidum* react strongly and regularly with Reiter lipopolysaccharide.

While a small group of normal human serums gave consistently negative results, a positive complement fixation test was obtained in 76 of 85 human syphilitic serums tested so far. Negative results have been observed in nine biologically false positive serums with more or less pronounced cardiolipin reactivity.

Chemical assays of the antigen are now in progress; a phosphorus content of 2·26 per cent has been found, indicating its lipopolysaccharide nature, which appears to be in keeping with *in vivo* and *in vitro* reactivity. From cross-absorption experiments it seems that the antibody reactive with the lipopolysaccharide antigen is not to be identified with either anti-lipid or with anti-protein antibody.

The consistently negative results observed when the lipopolysaccharide antigen is tested with normal rabbit serums or normal human serums and especially biologically false positive serums indicate the specificity of the antigen. The presence of the Reiter anti-lipopolysaccharide antibody in rabbits infected with the pathogenic Nichols strain, and in a high percentage of human syphilitic serums, strongly suggests that an identical or very similar lipopolysaccharide antigen is common to the Reiter and pathogenic *Treponema pallidum*.

Extensive research is needed in order to establish the practical importance of the lipopolysaccharide antigen in the serodiagnostic field. However, in our opinion modern syphilis serology will be based more and more on the detection of the three distinct anti-protein, anti-lipid and anti-lipopolysaccharide antibodies.

Giuseppe D'Alessandro
Carla del Carpio
Istituto d'Igiene e Microbiologia,
Università di Palermo. Jan. 8.

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Influence of 4-Methyl-2-thiouracil on the Teratogenic Activity of Hypervitaminosis-A

It has previously been reported that the incidence of deformities of the skull, brain and palate in the young of female rats exposed to the effects of hypervitaminosis-A during pregnancy is greatly increased if large quantities of cortisone are given to the dams during the period of vitamin A administration[1,2]. It has also been shown that this 'potentiating' action of cortisone in relation to hypervitaminosis-A can be abolished by the administration of insulin to the pregnant female[3].

It is apparent, therefore, that the endocrine glands may play an important part in regulating the teratogenic activity of vitamin A. The present communication is concerned with the influence of 4-methyl-2-thiouracil when administered in doses sufficient to cause loss of thyroid activity in the rat.

Female white rats of the Wistar strain, each of which had previously given birth to a normal litter, were used in these experiments. At the beginning of the experiments the rats were given 2,000 I.U. of vitamin D and 50 mgm. of vitamin E by mouth to ensure that they had an adequate supply of these vitamins. Day 1 of pregnancy was taken as the day on which spermatozoa were detected in the vagina at 9 a.m. The pregnant rats were divided into three groups.

Group 1 received 60,000 I.U. of vitamin A acetate daily from the eighth to the thirteenth day, inclusive, of pregnancy.

Group 2 received 60,000 I.U. of vitamin A acetate daily from the eighth to the thirteenth day, inclusive, of pregnancy and, from the first to the tenth days of pregnancy inclusive, was given a 0·1 per cent solution of 4-methyl-2-thiouracil in lieu of drinking water.

Group 3 was given a 0·1 per cent solution of 4-methyl-2-thiouracil in place of drinking water daily from the first to the tenth days of pregnancy inclusive.

Vitamin A was given by intubation. During the course of the experiment each rat in groups 2 and 3 received on average 240 mgm. of 4-methyl-2-thiouracil.

The rats were killed on the twentieth day of pregnancy and the young removed from the uterus and examined for deformities of the skull and brain. The deformity of the brain encountered was exencephaly.

The findings of the experiment are shown in Table 1. It will be noted that the number of young in group 2 is much smaller than that in the other two groups. This is due to the total resorption of the litters in ten animals.

Table 1

Group	No. of rats	Total No. of young	No. of young with deformities of brain and calvaria	Percentage of young with deformities of brain and calvaria
1	12	77	6	7·8
2	18	45	31	68·8
3	9	62	0	0

The most striking feature to emerge from these experiments is the marked effect of 4-methyl-2-thiouracil on the incidence of deformities of the skull and brain. In previous experiments in which cortisone was given in conjunction with vitamin A, the incidence of deformities of the skull and brain was 36·6 per cent. Cortisone was, however, administered on the ninth to twelfth days of pregnancy, that is, towards the end of the critical period for this deformity.

The results of these experiments suggest that 4-methyl-2-thiouracil has a potentiating effect on the teratogenic activity of vitamin A similar to that previously described for cortisone[1,2].

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D. H. M. Woollam
J. W. Millen

Department of Anatomy,
Cambridge.

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Effect of Trauma on Growth of Hair

It has recently been reported that ionizing radiations produce local stimulation of growth of hair in the rabbit[1]. Subsequent to this observation, the stimulating effect of some nitrogen mustard derivatives was recorded[2], and it was suggested that "It should be of interest to determine whether the observed effects can be obtained with other radiomimetic agents or carcinogenic substances".

It seems to me that no specific effect of radiation or radiomimetic agents is required to explain the observed phenomena. During studies on hair growth I have often observed that simple mechanical trauma such as scratching or cutting the rabbit skin causes a sudden hair growth to occur around the site of injury. The effect is most dramatically seen in the quiescent phase of the hair-growth cycle. A clipped area of skin may stay quiescent and free from hair for as long as 3–4 months at a time. Trauma to the centre of such an area results in growth of hair around the site of trauma, with the result that a tuft of hair is soon seen lying in the centre of the hairless zone. The accompanying photograph (Fig. 1) shows the effect of a small incision, 0·5 cm. long, into the entire thickness of the skin in the quiescent phase of the cycle. Failure to appreciate the mechanics of the hair-growth cycle has led to many errors in the past, and a brief summary of some of the important facts is as follows.

Hair replacement in the mouse[3,4], rat[5,6] and rabbit[7] is discontinuous and occurs in cyclical waves of active growth. In the mouse and rat cyclical waves of activity start on the ventral surface and spread upwards over the trunk. In the rabbit the hair replacement on the back and flanks occurs in a progressive cycle starting at the dorsum and spreading downwards

Fig. 1

over the flanks. Hair replacement on the abdomen occurs quite independently of the main dorso-lateral cycle. The progress of a cycle over the trunk creates linear bilaterally symmetrical bands of active growth which can be demonstrated clearly in the clipped animal.

There are many differences between such active and quiescent skin. Hair follicles in the active zone show significantly more mitoses than follicles in the quiescent zones[8]. Proliferative pathological lesions can also be induced more readily in areas where hair growth is active. Thus, painting the rabbit flank with carcinogen produces tumours more quickly and abundantly in an active zone[9]. Inoculation of Shope papilloma virus into skin showing active hair growth and into quiescent skin results in the development of larger and more numerous tumours in the active skin[10]. Intravenous inoculation of vaccina virus into rabbits showed that lesions almost invariably developed in the active zone[10].

In the guinea pig and in man there is no gross hair-growth cycle as seen in the rat, mouse or rabbit. Nevertheless, each hair does show an independent cycle of growth and quiescence. Thus hairs in anagen, catagen, and telogen may be seen lying side by side in any small area of skin in the guinea pig, but they are grouped together in the rabbit and show as large zones of actively growing hair or resting hair.

The problem of growth of hair in man and laboratory animals is of importance not only because of its intrinsic biological significance[6,11], but also because the effect of agents such as X-rays[1] and nitrogen mustards[2] on growth of hair can only be rationally analysed against a background of the dynamic hair-growth cycles and patterns.

F. N. Ghadially

Department of Pathology,
University of Sheffield.

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Rotatory Dispersion of Cytochrome *c*

The iron atom in hæm compounds has its six covalences directed toward the six corners of an octahedron; there are four co-planar bonds with the porphyrin nitrogen atoms and one bond on each side of the plane of the porphyrin. The only possible plane of symmetry in such molecules is the plane of the porphyrin; the iron must constitute a centre of asymmetry if one of two requirements is satisfied: (1) different groups are linked to iron on the two sides of the porphyrin plane or (2) groups co-ordinated to iron are also attached to porphyrin side-chains, thus forming chelate rings.

Both these conditions are fulfilled in cytochrome *c*, since the amino-acid composition differs on the two sides of the porphyrin[1], and since the protein is linked to both iron[2] and to porphyrin side-chain[3]. The iron atom of cytochrome *c* should, therefore, contribute to the optical activity of the molecule, unless it is racemized, and racemization is not expected in biological compounds.

It has been observed that the oxidized and reduced forms of *tris*-orthophenanthroline-ruthenium exhibit marked differences in optical rotation, with no change in the organic portion of the molecule[4]. Optical activity due to iron in cytochrome *c* may thus be differentiated from the optical activity due to the protein by looking for a difference in rotation resulting from the gain or loss of an electron.

Sigma cytochrome *c* was purified by passing it through a column of *XR*-64 resin[5]. A 0·5 *M* solution in phosphate buffer (*p*H 6·5) was oxidized with potassium ferricyanide, reduced with hydrogen over platinum, and re-oxidized with ferricyanide. Optical measurements were made in a 0·5 cm. cell at 26° with a Rudolf polarimeter, using a zirconium light source and a Beckman monochromator. Fig. 1 shows rotatory dispersion curves for the oxidized and reduced forms; the curve obtained by oxidation of the reduced form is identical with the curve for the solution prior to reduction.

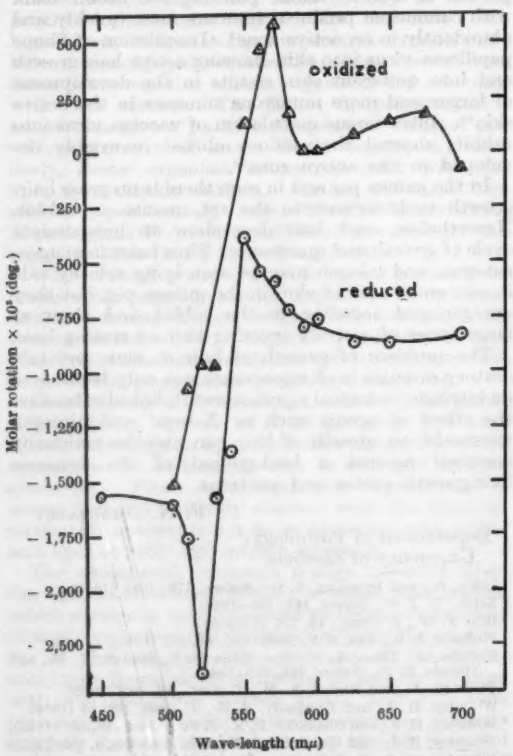

Fig. 1. Rotatory dispersion curves for cytochrome *c*. (S.D. ± 50 × 10⁻³ deg.)

Both oxidized and reduced cytochrome *c* show 'anomalous' dispersion in the region of 550 mμ, where the greatest difference exists in the spectra of the two forms[6]. The absorption in this region probably involves the absorption of the iron–nitrogen bonds; the 'anomalous' dispersion is another indication that the iron is asymmetric.

Similar investigations are being made for other biological porphyrin compounds.

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Gunther L. Eichhorn
Joan F. Cairns

Department of Chemistry,
Georgetown University,
Washington 7, D.C.

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Isolation of a Glycine-Carbohydrate Residue from Muscle Collagen

One of a group of related, macromolecular substances composed of an amino-acid linked to a polysaccharide has been isolated and partially characterized. This group of substances, obtained by means of proteolysis of muscle collagen by carboxypeptidase and subsequent electrophoresis of the non-dialysable fraction, suggests the existence of a polysaccharide residue linked to the C-terminal amino-acid.

Collagen was prepared from rat muscle by a combination of the methods described by Neuberger *et al.*[1] and by Fitch *et al.*[2], employed in the order stated. The collagen preparation used in these experiments was obtained from rats which had been injected intraperitoneally with eight doses of glycine-2-^{14}C (total counts per min. injected, $6{\cdot}35 \times 10^{8}$; specific carbon-14 activity, $1{\cdot}88 \times 10^{7}$ c.p.m./mgm.). The rats, which were killed 56 hr. after the injection of the last carbon-14 dose, were also used in related studies reported elsewhere[3]. Similar experiments using D-glucose-U-^{14}C will not be described here in detail.

In a typical experiment, 50 mgm. of muscle collagen was incubated at 37° C. for 20 hr. with 4 mgm. of thrice recrystallized carboxypeptidase in the presence

of 0·05 *M* phosphate buffer, *p*H 7·8 and 1·2 *M* lithium chloride. At the end of the incubation period trichloracetic acid was added to obtain a final concentration of 5 per cent, and the resulting precipitate was removed by centrifugation. The supernatant solution was extracted several times with ethyl ether. The residue obtained upon evaporation to dryness was taken up in a small volume of water and was dialysed against running tap water for 24 hr. Paper chromatography carried out subsequent to dialysis in the solvent system[4] 2-butanol/90 per cent formic acid/water, 75 : 15 : 10, v/v/v, revealed the presence of six ninhydrin-reactive substances, all of which had migrated from the starting point. In addition, there was found a large immobile fraction (*A*) which, when sprayed with aniline–phthalate reagent[5], formed a brownish-coloured spot. This spot fluoresced with a yellow colour in ultra-violet light and reacted with ninhydrin slowly to form a yellowish spot.

The entire immobile fraction (*A*) was isolated by means of a 'streak' chromatogram, developed in the solvent system mentioned earlier. This fraction was eluted in water at a slightly alkaline *p*H and a small aliquot was hydrolysed with 6 *N* hydrochloric acid in a sealed tube at 100° C. The following amino-acids could be identified in this hydrolysate: lysine, glycine, glutamic acid, alanine, leucine, phenylalanine, valine and serine. The remainder of the eluate was subjected to continuous paper electrophoresis in 0·090 *M* borate buffer, *p*H 7·8, for 24 hr. at 450 V. and 2–3 m.amp. The eluate was dropped on the centre of the paper sheet above tube No. 12 of a series of 22 tubes. (Tube No. 1 was at the anodic side and No. 22 at the cathodic side.) About 63 per cent of the total carbon-14 activity of the eluate was collected in tubes No. 11–16 (*B*), each tube containing 4 ml. The contents of these tubes were combined and rechromatographed by means of continuous paper electrophoresis at *p*H 5·4 in 0·025 *M* acetate buffer using 610 V. and 2–3 m.amp. Under these conditions, the fractions containing carbon-14 activity had migrated significantly toward the anode and were confined largely to three of the 22 tubes (No. 7–9. (*C*)). The combined contents of the three tubes were again subjected to continuous paper electrophoresis in 0·02 *M* phosphate buffer, *p*H 7·8, at 410 V. and 3 m.amp., whereupon, after 48 hr., almost all of the carbon-14 activity was found in four tubes (No. 11–14 (*D*)), each containing 3 ml. of effluent. Since the point of application of the solution to the paper was directly above tube No. 11, there was a slight displacement toward the cathode, as was the case with electrophoresis in borate buffer at *p*H 7·8. The contents of tubes No. 11–14 were pooled, evaporated to dryness *in vacuo* and the resulting residue subjected to reductive cleavage by adding 500 mgm. of lithium borohydride and 50 ml. of tetrahydrofurane to the dry residue. This reaction was carried out at 65° C. for 5 hr.[6].

Finally, the solution was made 6 *N* with respect to hydrochloric acid and hydrolysed in a sealed tube at 100° for 20 hr. after dinitrophenylation. Paper chromatography in the solvent system described by Grassmann *et al.*[7] yielded only one dinitrophenyl derivative, namely, that of ethanolamine. These findings suggest that glycine is the only amino-acid present in the fraction isolated by continuous paper electrophoresis and that the remainder of the molecule is composed of a substance with macromolecular dimensions, presumably a polysaccharide. Electrophoretic studies of the material remaining after lithium borohydride reduction indicate the presence of a positively charged molecule, the positive charge being perhaps due to the amino-group in hexosamine residues. The carbon-14 activities present in the initial sample of collagen and in various derived fractions are shown in Table 1.

Table 1. Total Carbon-14 Activity in Fractions Isolated

Fraction	Total carbon-14 activity in fraction (c.p.m.)
Muscle collagen	90,100
Immobile fraction (*A*)	26,000
Electrophoresis in borate buffer (*B*) (tubes No. 11–16)	16,553
Electrophoresis in acetate buffer (*C*) (tubes No. 7–9)	2,069
Electrophoresis in phosphate buffer (*D*) (tubes No. 11–14)	563

The findings reported here indicate that the polysaccharide moiety of collagen is indeed linked to certain C-terminal amino-acids and that this polysaccharide–amino-acid complex is split by carboxypeptidase from the polypeptide chain as an intact macromolecule. One such complex was characterized further by demonstrating the presence of a single amino-acid (glycine) by means of reductive cleavage with lithium borohydride.

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K. Konno
K. I. Altman

Department of Experimental Radiology,
University of Rochester
School of Medicine and Dentistry,
Rochester,
New York.

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Incorporation of Disodium *p*-Nitrophenylphosphate in Solid Medium for the Detection of Phosphatase Production by *Micrococcus pyogenes* var. *aureus*

The production of phosphatase by *Micrococcus pyogenes* var. *aureus* has been demonstrated using a solid medium incorporating phenolphthalein phosphate[1]. The presence of phosphatase has also been correlated with coagulase production[2], which in turn has been shown to be linked with exotoxin production[3]. Therefore it is assumed that all exotoxin-producing staphylococci are coagulase- and phosphatase-positive. The quantitative study of the phosphatase activity of *Micrococcus pyogenes* var. *aureus*[4] has shown that the production of phosphatase can be used as an index to toxin production.

A medium incorporating disodium *p*-nitrophenylphosphate has been devised in this laboratory with the object of using a single medium for the detection of *Micrococcus pyogenes* var. *aureus* in spray-dried milk powders. Preliminary trials have confirmed earlier work that the use of disodium *p*-nitrophenyl

phosphate is much superior to other phosphatase substrates.

The medium consists of nutrient agar to which is added a sterile solution of disodium *p*-nitrophenyl phosphate. This medium is used in the normal way. The streaked Petri dishes are examined after 24-hr. incubation at 37° C. and the presence of phosphatase is indicated by the yellow colour of liberated *p*-nitrophenol surrounding colonies of *M. pyogenes* var. *aureus*. Positive results are readily discernible after 16–18-hr. incubation.

The incorporation of high concentrations of sodium chloride in the media has only a slightly inhibiting effect on phosphatase production. This effect is less than the inhibition caused by sodium chloride in a medium using phenolphthalein phosphate as substrate[1], probably because of the high sensitivity of the disodium *p*-nitrophenylphosphate[2].

Investigations are proceeding to determine the optimal level of substrate concentration and to examine the incorporation of inhibiting agents for Gram-negative organisms.

H. R. Lovell

Fisons Milk Products, Ltd.,
Coleraine.
Jan. 7.

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Metabolic Role of Xanthopterin

Albert[1] has suggested that xanthopterin would be found in higher amounts in neoplastic tissues than in normal. In anticipation of confirming this by direct experiment, we have analysed for their pterin content, normal kidney tissue of the golden hamster and transplantable neoplasms in the golden hamster, derived from stilbœstrol-induced renal tumours[2]. No xanthopterin could be found. The largest amount of tissue used was 1 gm. of normal tissue and 8 gm. of neoplastic tissue, and the smallest amount of xanthopterin that could be detected by the paper chromatographic technique used was 0·1 μgm.

Xanthopterin has been isolated from human urine[3]. If, however, xanthopterin is present as a tissue metabolite, some of it should be oxidized to leucopterin by xanthine oxidase[4]. This expectation is borne out by the occurrence of leucopterin in the kidney tubules of golden hamsters given massive doses of xanthopterin[5]. An analysis of human urine failed to reveal leucopterin (which would have been found between the origin and 2-amino-4-hydroxypteridine-6-carboxylic acid in the propanol–5 per cent aqueous acetic acid (2:1 v/v) solvent system used)[6].

Kalckar *et al.*[7] found that xanthopterin was not present in freshly voided urine, but that a colourless non-fluorescent substance was present which was converted to xanthopterin by air oxidation. Futterman and Silverman[8] found a labile substance in human urine the properties of which resembled an unformylated reduced folic acid, and Blakley[9] has demonstrated that di- and tetra-hydrofolic acids are readily oxidized to xanthopterin.

Slavik *et al.*[10] found xanthopterin in the urine of rats fed tetrahydrofolic acid but showed that the xanthopterin was formed during isolation by the non-enzymic oxidation of tetrahydrofolic acid.

The present burden of evidence is therefore that xanthopterin is absent from mammalian tissues. The biological effects of xanthopterin in mammals should therefore be attributed only to the disturbance of a normal metabolic pathway by an artificially introduced substance.

A fuller account of this work will be published elsewhere in due course.

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J. A. Blair

University College of Ghana,
Achimota, Ghana.

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Chromatographic Separation of Lactalbumin from Human Milk Whey on Calcium Phosphate Columns

According to Deutsch[1] and Wegelin[2] bovine and human milk wheys differ to a certain extent in electrophoretic patterns. On the basis of paper electrophoretic data, Fontaine[3] considers it probable that the electrophoretic fractions in human milk whey closely correspond to different proteins found in bovine whey (serum albumin, β-lactoglobulin, α-lactalbumin and immune globulins). As part of an investigation of the protein composition of human milk whey and its relation to bovine whey, I have studied the separation of a crude 'albumin'-fraction from human milk by means of chromatography on calcium phosphate.

Pooled, frozen human milk or fresh milk was used. After defatting the milk by centrifugation, the lactalbumin fraction was obtained by salting out with ammonium sulphate in the following way. A crude fraction consisting of casein and lactoglobulins was removed at 50 per cent saturation. The lactalbumin fraction was then precipitated by saturating the remaining solution with ammonium sulphate. This crude albumin consisted of three main components judging by paper electrophoresis (Fig. 1).

The calcium phosphate gel was prepared according to Tiselius[4]. 250-mgm. samples of lyophilized protein were dissolved in 10 ml. 0·03 *M* sodium phosphate buffer *p*H 6·9, containing 0·1 *M* sodium chloride. This solution was applied to calcium phosphate columns, 2·8 cm. × 8 cm., previously washed with the same buffer solution. Elution was performed with a slight external pressure giving a flow-rate of approximately 20 ml./hr. The effluent was collected in 5-ml. fractions and the protein concentration of each

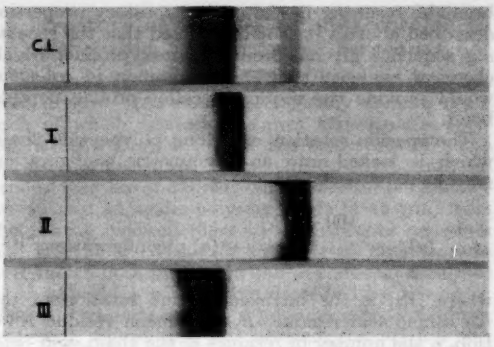

Fig. 1. Paper electrophoretic patterns of crude, human lact-albumin (*C.L.*) and different fractions obtained by chromatography on calcium phosphate

fraction arbitrarily determined at 280 mμ in a Beckman *DU* spectrophotometer. A typical chromatogram is shown in Fig. 2. Elution with step-wise increased concentrations of phosphate buffer gave three peaks at 0·03 *M*, 0·12 *M* and 0·5 *M*, respectively. With these concentrations no considerable tailing occurred. The different fractions were thoroughly dialysed against ice-cold distilled water and lyophilized. The yields of the different fractions estimated by Kjeldahl determinations were I, 45 per cent, II, 10 per cent, III, 30 per cent, the total yield thus amounting to 85 per cent. The reproducibility of two chromatographic runs on the same albumin preparation was found satisfactory. By paper electrophoretic investigations of the fractions (Fig. 1), fraction I was shown to be essentially homogeneous in veronal buffer at *p*H 8·6. However, electrophoresis by the moving-boundary method revealed a small impurity with lower mobility (Fig. 3). The protein appeared homogeneous in the ultracentrifuge with a sedimentation constant

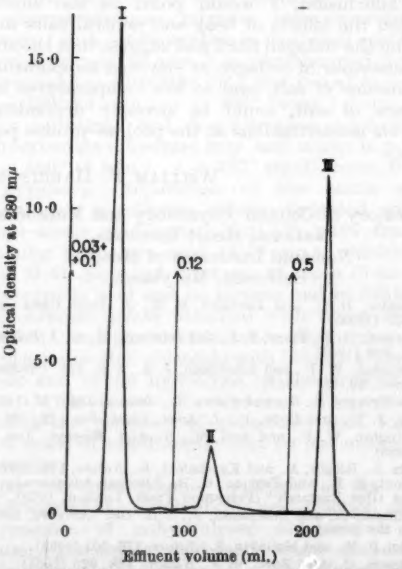

Fig. 2. Chromatography of crude human lactalbumin on calcium phosphate. Stepwise elution with 0·03 *M*, 0·12 *M* and 0·5 *M* phosphate buffer

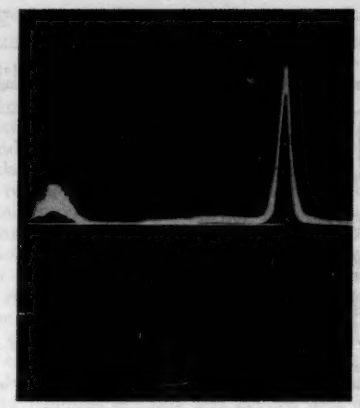

Fig. 3. Boundary electrophoresis of fraction I. Protein concentration 1 per cent. Veronal buffer: *p*H = 8·6, μ = 0·1. Ascending limb after 7,200 sec.

of 1·73 S., the value of which is very similar to the sedimentation constant of 1·75 S. for α-lactalbumin isolated from bovine milk whey[5]. Fraction II consisted electrophoretically of at least 80 per cent of a protein with the same mobility as human serum albumin. It was also immunologically identical with serum albumin when tested by Ouchterlony's technique[6]. In fraction III mainly a salmon-coloured component was found containing small amounts of iron, which could not be removed by passing the protein through a column with a cation exchange resin ('Dowex 50, *X*–12') at *p*H 6·9. Examination of the light absorption of the component in a wavelength range of 350–1,000 mμ revealed only a flat maximum at 460–470 mμ. No Soret band could be obtained.

A more detailed communication concerning the isolation, composition and properties of the fractions described will be published later.

I am indebted to Mrs. Birgit Johansson for skilful technical assistance.

BENGT JOHANSSON

Department of Medical Biochemistry,
University of Gothenburg.

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Effect of Neutral Salts on the Structure of Collagen and Gelatin

IN a current project in this laboratory, the optical rotatory properties of aqueous solutions of gelatin and soluble collagen from three different species of vertebrates have been examined in the absence and presence of lithium bromide. Results (Table 1) are in general agreement with the earlier work of Carpenter and Lovelace on bovine gelatin[1]. It will be observed that, although striking changes occur in the specific rotations of collagen and gelatin in the presence and absence of salt, the value of λ_c (obtained from the slopes of linear Drude plots of $\lambda^2[\alpha]$ vs. $[\alpha]$)

Table 1. Effect of Salts on Optical Rotatory Properties of Collagen and Gelatin

Material	Solvent	$[\alpha]_D^{25}$*	λ_c (mμ)	$[\alpha]_D$† configuration (calc.)
Rat tail collagen	Water	−289°	217	−200°
Rat tail gelatin	Water	−118°	217	−30°
Rat tail gelatin‡	12 *M* LiBr	−35°	207	+53°
Ichthyocol collagen	Citrate (μ 0·05, pH 3·7)	−330°	204	−240°
Ichthyocol gelatin (Ref. 12).	Citrate (μ 0·05, pH 3·7)	−110° (41° C.)	204	−20°
Ichthyocol gelatin	2 *M* KSCN	−86°	204	+4°
Ichthyocol gelatin‡	12 *M* LiBr	−56°	202	+34°
Bovine collagen	0·2 *M* KCl	−350°	220	−258°
Bovine gelatin	0·2 *M* KCl	−146°	217	−54°
Bovine gelatin	8·5 *M* LiBr	−60°	198	+32°

* Corrected for index of refraction.

† For amino-acid compositions of rat-tail, ichthyocol and bovine collagens, see ref. 11.

‡ Prepared by adding lithium bromide solution to the solid collagen.

changes only slightly and, if anything, may decrease somewhat.

The gelatin molecule in solution exhibits hydrodynamic properties approaching those expected for a random chain[3]. Consequently, a lowering of the water activity through addition of lithium bromide should favour a hydrogen-bonded configuration, as is observed in the case of oxidized ribonuclease, clupein, silk fibroin and serum albumin[3]. On the other hand, the high proline and hydroxyproline content of gelatin is not compatible with the formation of an α-helix if we assume that the proline residues do not exist as blocks in the polypeptide chain[4]. Moreover, a number of observations have demonstrated that the transition from a partially folded or random polypeptide chain structure to an extensively hydrogen-bonded configuration, although leading to a decrease in the absolute value of the specific rotation, is invariably reflected in an increase[5] in the value of the Drude dispersion parameter, λ_c, of between 30 and 100 mμ. Such a transition for a polypeptide chain of the molecular weight of bovine gelatin ($2–4 \times 10^5$ (ref. 2)) should also lead to a significant increase in the intrinsic viscosity of the solution. However, viscosity measurements on solutions of a commercial bovine gelatin in 0·2 *M* potassium chloride and in 8·5 *M* lithium bromide at a temperature of 35° C. yield, within the experimental error, the same intrinsic viscosity, namely, 0·39 (gm./100 ml.)$^{-1}$. The optical rotatory properties of gelatin in the presence of high concentrations of neutral salts cannot, therefore, represent the development of any extensive hydrogen-bonded configuration.

Recently[6], we have found significant alterations in the optical rotatory characteristics of aqueous solutions of poly-L-proline II[7] in the presence of lithium bromide and certain other salts. (Poly-L-proline exists in two forms, one exhibiting a specific rotation $[\alpha]_D^{25} = +40°$ in water (polyproline I) and the other exhibiting a specific rotation, $[\alpha]_D^{25} = -540°$ (polyproline II).) Thus $[\alpha]_D^{25}$ decreases from a value of −540° (in water) to about −250° (in 12 *M* lithium bromide), whereas, from linear Drude plots of the rotatory dispersion, λ_c is lowered from 202 mμ to about 185 mμ. These changes have been interpreted as resulting from a series of *trans–cis* isomerizations at the proline–proline peptide bonds of the polymer. Whatever the true nature of these changes, it would seem possible for similar phenomena to occur in solutions of soluble collagen and gelatin in lithium bromide, resulting in the optical rotatory properties described above. It should be noted that the repeating sequence glycine–proline–hydroxyproline, which chemical evidence suggests is common in collagen, would provide the required proline–proline peptide bond.

The specific rotation of a long polypeptide chain which is locked into an asymmetric configuration may be expressed as:

$$[\alpha]_D = \frac{100 \Sigma [R_i]}{n R_m} + [\alpha]_D, \text{ configuration}$$

where $[R_i]$ is the intrinsic residue rotation of the ith amino-acid residue, R_m the mean residue rotation, n the number of residues in the chain, and $[\alpha]_D$, configuration, the structural contribution of the chain. $[R_i]$ of glycine may be taken as zero, that of proline and hydroxyproline[6] as −250°, and that of all other amino-acids[8] as about −110°. From the known compositions of the three gelatins and their specific rotations we have estimated the structural contribution, $[\alpha]_D$, configuration, in water and in concentrated lithium bromide (Table 1).

Inspection of Table 1 reveals a residual amount of left-handed (−) asymmetry (in the absolute sense, in conformity with the screw sense of polyproline II[9]) remaining in each of the gelatin molecules in water and in dilute salt solutions. Moreover, all the gelatin structures have a significant amount of right-handed (+) configuration in aqueous lithium bromide which, by analogy with the studies on polyproline II, could result from *trans–cis* isomerizations at the proline–proline peptide bonds. The three collagens in water exhibit very strong left-handed structural contributions, the values for $[\alpha]_D$, configuration approaching that found[6] for the proline II helix in water (−300°). The possibility that gelatin retains some polyproline II-like structure in water may be of importance in the association of gelatin molecules at low temperature to give the collagen fold[10].

In conclusion, I would point to the similarity between the effects of heat and neutral salts in contracting the collagen fibril and suggest that the shrinkage behaviour of collagen at elevated temperatures in the absence of salt, and at low temperatures in the presence of salt, could be strongly dependent on *trans–cis* isomerizations at the proline–proline peptide bonds.

William F. Harrington

Laboratory of Cellular Physiology and Metabolism,
National Heart Institute,
National Institutes of Health,
Bethesda, Maryland.

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Structure of an Acidic Polysaccharide elaborated by *Aerobacter aerogenes*

Organisms of the *Aerobacter–Klebsiella* group have been divided[1] into many serologically distinct types each of which produces its own type-specific polysaccharide. Only a few of the structures of these polysaccharides have been elucidated[2–4] since in general they are of a highly complex nature. Recently we isolated an acidic polysaccharide (4·45 gm.) from the culture medium (38·4 l.) of *Aerobacter aerogenes* N.C.T.C. 8172 (*Klebsiella* type 64). The bacteria were grown both in batches and in continuous culture in an apparatus of the type described by Elsworth, Meakin, Pirt and Capell[5]. A peptone–glucose medium was used, the culture was aerated, the *p*H 5·0 and the temperature, 37°. The acidic polysaccharide was freed from neutral polysaccharide by precipitation with 'Cetavlon'[6] and from nucleic acid by the preferential solubility of its cetyl trimethyl ammonium salt in 0·25 *M* sodium chloride. Isolated as its sodium salt, the acidic polysaccharide had C, 45·31; H, 6·19; N, 0·81; P, 0·11 per cent and its ultra-violet absorption at 260 mμ corresponded to about 1·8 per cent nucleic acid impurity. The polysaccharide contained 28·7 per cent uronic acid (by decarboxylation[7]) and the infra-red spectra of the polysaccharide as the free acid and as the sodium salt confirmed the presence of carboxylic acid groups[8]. The polysaccharide showed $[\alpha]_D^{17}$ + 29·4° (conc. 0·272 in *M* sodium chloride).

Acidic hydrolysis of the polysaccharide (3·7 gm.) with 2 *N* sulphuric acid (75 c.c.) at 100° for 3 hr. and separation of the neutralized hydrolysate on 'Deacidite *FF*' (carbonate form) gave neutral sugars (2·3 gm.) and acidic sugars (1·03 gm.). Separation of a portion (2·0 gm.) of the neutral sugars on a cellulose column irrigated with butanol, ethanol, water, ammonia (40 : 10 : 49 : 1) gave one fraction (0·295 gm.) containing rhamnose and another (1·5 gm.) containing a glucose–mannose mixture. The rhamnose was obtained as crystalline α-L-rhamnose, m.p. and mixed m.p. 93–94°, $[\alpha]_D^{22}$ + 8·2° equil. (conc. 4·13 in water). The glucose–mannose mixture was separated by treatment[9] with *p*-nitroaniline in methanol containing hydrochloric acid to give N-*p*-nitrophenyl-β-D-glucopyranosylamine dihydrate m.p. and mixed m.p. 184°, $[\alpha]_D^{22}$ − 196° (4 min.) → − 203° (equil.) (conc. 1·02 in dry pyridine), and N-*p*-nitrophenyl-β-D-mannopyranosylamine dihydrate m.p. and mixed m.p. 219°, $[\alpha]_D^{22}$ − 400° (4 min.) → − 333° equil. (conc. 0·12 in dry pyridine). Separation of the acidic sugars (1·0 gm.) on a cellulose column irrigated with *n*-butanol–acetic acid–water (4 : 1 : 5) gave fractions containing hexuronic acid (0·02 gm.), aldobiuronic acid(s) (0·41 gm.) and mixtures of these (0·45 gm.). The hexuronic acid and its lactone had mobilities on paper chromatograms identical with those of glucuronic acid and glucuronolactone. Reduction of its methyl ester methyl glycoside with lithium aluminium hydride and acidic hydrolysis of the product gave glucose with traces of mannose. This evidence indicated the presence of glucuronic acid together with a trace of mannuronic acid in the acidic polysaccharide.

Paper chromatographic analysis of an acidic hydrolysate of the aldobiuronic acid fraction showed the presence of unhydrolysed aldobiuronic acid, mannose, glucuronic acid and small amounts of glucose. Similar analysis of a hydrolysate of the reduced aldobiuronic acid fraction showed the presence of approximately equal amounts of glucose and mannose. No rhamnose was detected either in the aldobiuronic acid hydrolysate or that of its reduction product. This evidence indicates that the major component of the aldobiuronic acid fraction was a glucuronosyl–mannose.

The acidic polysaccharide consumed 0·303, 0·331, 0·337 and 0·423 moles of periodate per 162 gm. of polysaccharide after oxidation for 48, 72, 96 and 110 hr. respectively. The corresponding values for formic acid produced were 0·06, 0·091, 0·1 and 0·11. Paper chromatographic analysis of a hydrolysate of the periodate oxidized polysaccharide showed the presence of glucose, mannose and glucuronic acid, but no rhamnose. These results indicate (*a*) that rhamnose is present either as end groups or linked through the 2- or 4-position, (*b*) that the maximum number of residues present as end groups or linked 1 : 6 is about 11 per cent, (*c*) that most of the glucuronic acid residues are not end groups and (*d*) that large numbers of glucose, mannose and glucuronic acid residues are linked either 1 : 3 or are involved in branching.

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S. A. Barker
A. B. Foster
I. R. Siddiqui
M. Stacey

Chemistry Department,
The University, Edgbaston,
Birmingham 15.

S. J. Pirt

Microbiological Research Establishment,
Porton, Wilts. Feb. 6.

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Colorimetric Detection of Human Cæruloplasmin Oxidase Activity after Electrophoresis in Agar Plates or after Immuno-electrophoresis

The use of colour reactions combined with electrophoretic analytical methods in agar plates has allowed double (electrophoretic mobility and chemical nature) or triple (electrophoretic mobility, immunochemical specificity and chemical nature) characterization of proteins, lipids, glycoproteins and phospholipids in a variety of biological fluids[1].

Cæruloplasmin, the blue protein of human serum, was isolated in 1948 by Holmberg and Laurell[2] and characterized as an α_2-globulin containing copper. They also showed that the substance exhibited oxidase activity with a variety of substrates.

In previous work[3], we have studied this protein by electrophoretic and immuno-electrophoretic analysis followed by the colorimetric detection *in situ* of copper-bound cæruloplasmin. In order further to identify cæruloplasmin by another of its inherent

properties, we have also developed a method for the detection of its oxidase activity.

The oxidizable substrates that we employed have previously been used in manometric[2] and spectrophotometric[4] methods for the estimation of the oxidase activity of cæruloplasmin. The method to be described is based on the fact that the final oxidation product of *p*-phenylenediamine is a quinoid compound insoluble in water called Bandrowski's base[5]. The formation of this deep brown base makes possible *in situ* measurement of the enzymatic activity of cæruloplasmin on compounds which have first been submitted to electrophoretic or immuno-electrophoretic analysis in agar gel. The apparatus employed and the method of agar electrophoresis have been described by Grabar and Williams[6].

Samples of human serum (0·02 ml. per analysis) or a solution of cæruloplasmin in 0·06 *M* sodium chloride (50 μgm. per analysis) are subjected for 4–5 hr. to a potential difference of 4–5 V./cm., in 1–1·2 per cent agar gel (3–4 mm. thick) containing a veronal buffer (*p*H 8·2, Γ/2 0·03).

We have employed the immuno-electrophoretic method of Grabar and Williams using the serum of horses immunized against whole human serum. When the lines of specific precipitation have formed, the plates are washed for three days in a solution of 0·15 *M* sodium chloride, which is changed once or twice a day.

After electrophoresis or after immuno-electrophoresis, the procedure is continued in the following manner. The plates are immersed in a 5×10^{-3} *M* solution of *p*-phenylenediamine in acetate buffer (*p*H 5·7, Γ/2 0·1) prepared immediately before use. In this solution they are incubated at 37° C. for 2 hr. At the end of the incubation period the position of the portions with oxidase activity is indicated by brownish spots or lines.

The plates are then washed twice for successive periods of two hours each in a solution of sodium acetate–acetic acid buffer (*p*H 4·7, Γ/2 0·1). This stops enzymatic activity and rids the agar plates of excess *p*-phenylenediamine. A typical result of such a run with normal human serum is shown in Fig. 1. The oxidase activity is seen as a zone corresponding to that of α_2-globulin. Only one of the lines of precipitation corresponding to the 18–20 antigenic constituents of human serum possesses oxidase activity with regard to *p*-phenylenediamine. The groups responsible for enzymatic activity are not blocked by the antigen–antibody combination. When sodium azide (10^{-3} *M*) is added to the solution of oxidizable substrate all enzymatic activity of the cæruloplasmin is destroyed.

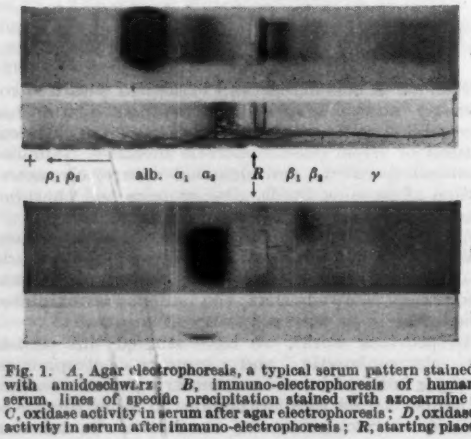

Fig. 1. *A*, Agar electrophoresis, a typical serum pattern stained with amidoschwarz; *B*, immuno-electrophoresis of human serum, lines of specific precipitation stained with azocarmine; *C*, oxidase activity in serum after agar electrophoresis; *D*, oxidase activity in serum after immuno-electrophoresis; *R*, starting place

Methods for the estimation of oxidase activity of cæruloplasmin in whole serum, either by oxygen consumption in the Warburg apparatus or by spectrophotometric determination, are open to the criticism that other redox systems in serum may act as competitive inhibitors on the substrate, *p*-phenylenediamine. Preliminary dialysis of the serum might prevent such interference in the case of small molecules (ascorbic acid, etc.), but it would be ineffective in the case of certain reducing groups on the surface of protein molecules.

With our technique the risk of encountering such difficulties is considerably lessened because of the preliminary electrophoretic separation of the protein constituents of the serum, and is practically negligible after immuno-electrophoretical analysis. We are now studying the exact conditions necessary for the quantitative estimation *in situ* of this enzymatic activity; preliminary results indicate that it will be possible to obtain quantitative measurements with the method[7].

A similar procedure to that reported here has been applied to the detection of catalase and peroxidase activities in hæmoglobin after electrophoretic separation in agar gels[7].

José Uriel

Service de Chimie Microbienne,
Institut Pasteur,
Paris.

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Microwave Spectra of Diazomethane and its Deutero Derivatives

We have measured rotation spectra, in the frequency-range 19,000–90,000 Mc./s., for three isotopic forms of diazomethane, and obtained the constants shown in Table 1, in Mc./s. A preliminary value of $1{\cdot}4_3 D$ is obtained for the dipole moment of diazomethane from Stark effect measurements on the $0_{00} \rightarrow 1_{01}$ transition. Nuclear quadrupole hyperfine structure is resolvable; its analysis is at present incomplete.

Table 1

Molecule	$(B_0 + C_0)$	$(B_0 - C_0)$	D_{JK}	D_J
CH_2N_2	22,150·7 ± 0·2	460·2 ± 0·2	0·39 ± 0·01	< 0·01
$CHDN_2$	20,640·7 ± 0·2	578·3 ± 0·2	0·27 ± 0·01	< 0·01
CD_2N_2	19,389·0 ± 0·2	696·2 ± 0·2	~0·2	—

The constants for CH_2N_2 correspond to a value of $(B_0 + C_0)/2$ equal to 0·369433 ± 0·000004 cm.$^{-1}$, compared with 0·368 cm.$^{-1}$ obtained from infrared spectra by Mills and Thompson[1], and with 0·371 cm.$^{-1}$ derived from similar data by Fletcher and Garrett[2]. Our results are consistent with the planar structure with C_{2v} symmetry indicated by

the infra-red spectra. The moment of inertia, I_A, found for CH_2N_2 from the relationship $I_A = I_B - I_C$ is $3{\cdot}15 \times 10^{-40}$ gm. cm.^{2}, which is slightly greater than the value reported from infra-red measurements[2]. Independent estimates of I_A from the present microwave R-branch transitions are in agreement, but are necessarily approximate, and we expect to determine accurate values of I_A from Q-branch spectra. In view of the inertial quantum defect found for ketene, a rather similar molecule, from its microwave spectrum[3], the present agreement with the infra-red value of I_A is satisfactory.

If any quantum defect is ignored, and the effects of zero-point energies on internuclear distances are neglected, the following structure-parameters are consistent with the microwave data: $d_{CH} = 1{\cdot}08$ A., $\angle HCH = 127°$, $d_{CN} = 1{\cdot}32$ A., $d_{NN} = 1{\cdot}12$ A. and $d_{CN} + d_{NN} = 2{\cdot}442 \pm 0{\cdot}005$ A. Because the central nitrogen atom is very close to the centre of gravity of the molecule, all the parameters, except $d_{CN} + d_{NN}$, can be varied considerably in proper phase with each other without excessive disagreement with the data. The above has been selected from the possible structures as reasonably consistent with all the evidence. There is general agreement with the electron diffraction results[4], but $d_{CN} + d_{NN}$ is considerably shorter than the upper limit allowed by the diffraction data.

To date we have detected no spectra attributable to a tautomeric form of diazomethane, the presence of which was suggested from infra-red evidence by Mills and Thompson[1]. A further search for such absorptions will be made, but there are indications[5] that the stability of the tautomer may be no greater than that of normal diazomethane, which decomposes with a half-life of the order of a minute in waveguide cells of copper or coin-silver cooled to − 70° C. for most of their length.

Other aspects of the spectra are under investigation, and detailed results will be communicated later. We are grateful to Mr. J. S. Heeks for assistance with these measurements.

A. P. Cox
L. F. Thomas
J. Sheridan

Department of Chemistry,
The University,
Birmingham 15. Dec. 20.

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Correlations between Localization Energies and Polarographic Half-Wave Potentials of Aromatic Hydrocarbons

Basu and Bhattacharya[1] recently claimed to have established a linear correlation between *para*-localization energies and polarographic half-wave potentials for some polynuclear hydrocarbons. Objections to their work have been raised by Pullman[2] and Fernandez-Alonso and Domingo[3], who criticize the values of the localization energies selected by Basu and Bhattacharya. All these authors use the polarographic data of Wawzonek and Laitinen[4], but all of them appear to have misunderstood the latter workers' statement that polarographic reduction consists of a two-electron addition process. It is true that the overall reaction consists of the addition of two electrons. But it is clear from the work of Wawzonek and Laitinen themselves, as well as from that of later authors[5–7], that the addition takes place by two one-electron steps. The least negative half-wave potential might therefore be expected to characterize the energy required to add *one* electron to the aromatic system, but could scarcely be related to the *para*-localization energy, which is a measure of the ease of addition to *two* positions in a hydrocarbon simultaneously[8].

A correlation between half-wave potentials and the localization energy for a single position is to be expected, since a straight line relation has already been reported between the latter and the logarithm of the methyl affinity[9,10], and another between log (methyl affinity) and half-wave potential[11]. This expectation is realized fairly satisfactorily in Fig. 1, where half-wave potentials measured in 'Cellosolve' solution by Bergman[12] are plotted against localization energies calculated by Coulson[9] (see also ref. 13), and by Dewar[14]. But it may be questioned whether this last correlation has theoretical significance, for the following reason. Coulson[9] and Szwarc[10] in relating methyl affinities to localization energies made the usual assumption that in the transition state the methyl radical is bound to a particular carbon atom which has sp^3 hybridization. On the other hand, Matsen[11], in correlating methyl affinities with half-wave potentials, suggested that the odd electron of the radical enters the lowest unoccupied orbital without binding the methyl to any particular carbon atom; electrons added by polarographic reduction are also believed (for example, ref. 15) to enter the π-electron system in the same way and thus be delocalized. Hence the bases of the two earlier correlations seem to be incompatible.

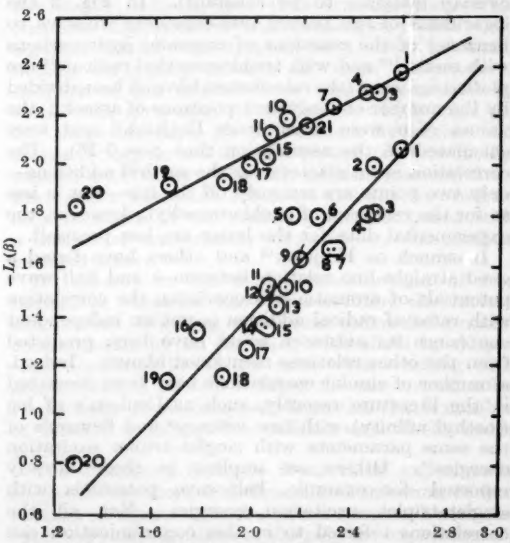

Fig. 1. Relations between localization energies and half-wave potentials. (*Upper curve*, localization energies of Coulson; *lower curve*, those of Dewar.) *Key:* 1, diphenyl; 2, triphenylene; 3, naphthalene; 4, phenanthrene; 5, coronene; 6, 3:4-benzophenanthrene; 7, chrysene; 8, picene; 9, 1:2-benzopyrene; 10, pyrene; 11, 1:2-5:6-dibenzanthracene; 12, 1:2-3:4-dibenzanthracene; 13, 1:2-7:8-dibenzanthracene; 14, pentaphene; 15, 1:2-benzanthracene; 16, perylene; 17, anthracene; 18, 3:4-benzopyrene; 19, naphthacene; 20, pentacene; 21, *trans*-stilbene

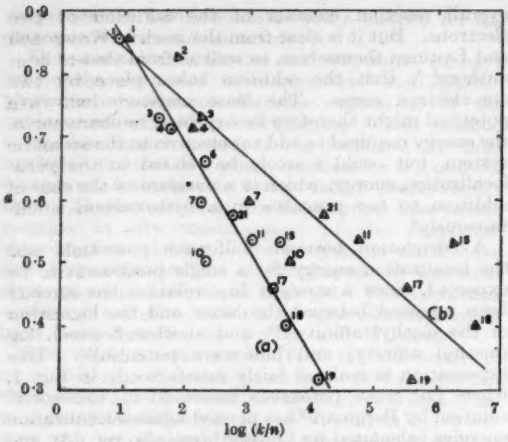

Fig. 2. Relations between partial rate factors of free radical additions and the root a of molecular orbital secular equation. (a), Addition of methyl; (b) trichloromethyl. (For key to points, see caption to Fig. 1)

This incompatibility may be less serious than appears at first sight: it has been pointed out[8] that the state visualized in the concept of localization energy is farther along the reaction path than the transition state (see also ref. 16), and therefore Matsen's suggestion may correspond to a different state, closer to the transition state itself. If this were true then the root, a, of the molecular orbital secular equation corresponding to the lowest unoccupied π-electronic level of aromatic hydrocarbons should predict correctly the relative reactivity of hydrocarbons to free radicals (assuming the resonance and overlap integrals to be constant). In Fig. 2 the logarithms of the partial rate-constants (relative to benzene) of the reactions of aromatic hydrocarbons with methyl[17] and with trichloromethyl radicals[13] are plotted against a (the rate-factors have all been divided by the number of equivalent positions of attack; the values of a were taken from Hoijtink[15] and were calculated on the assumption that $S = 0{\cdot}25$). The correlation is satisfactory for the methyl additions—only two points are seriously off the line—but is less so for the reactions of trichloromethyl; however, the experimental data for the latter are less precise[13].

Inasmuch as Hoijtink[15] and others have found a good straight-line relation between a and half-wave potentials of aromatic hydrocarbons, the correlation with rates of radical addition is not an independent one (since its existence could have been predicted from the other relations mentioned above). Indeed, a number of similar correlations have been described in the literature recently, such as Coulson's of log (methyl affinity) with free valency[9] and Szwarc's of the same parameters with singlet–triplet excitation energies[10]. Others are implicit in those already reported—for example, half-wave potentials with singlet–triplet excitation energies. Not all the correlations referred to in this communication can be of fundamental significance; distinguishing the fundamental from the coincidental should be a fruitful study for those concerned with the theory of reaction mechanism.

As already stated, the polarographic data of Bergman[12] were used in plotting Fig. 1; the half-wave potentials determined by Hoijtink *et al.*[6] using a 96 per cent dioxan–water mixture as solvent are on the whole closely similar to those of Bergman, but give a slightly less satisfactory plot against localization energy.

P. H. Given

British Coal Utilisation Research Association,
Randalls Road,
Leatherhead.

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Niobium in Sea-water

The presence of organically bound niobium has been demonstrated in ascidians[1], and unpublished evidence suggests that this niobium is absorbed in some way from sea-water. It is thus of importance to know if niobium can be detected in sea-water and to obtain some indication of its concentration. Consideration of the known amounts of niobium present in an adult *Molgula manhattensis*, its rate of development, length of life and rate of filtration of water leads one to suppose that if the water current is the sole source of niobium then, in regions where these species and other species of ascidians which utilize niobium flourish, it cannot be present in the sea in less concentration than 0·05 μgm./l. The chromatographic method of niobium analysis developed by Hunt, North and Wells[2] is capable of revealing the presence of 10^{-7} gm. of niobium. At a concentration of 0·05 μgm./l., this amount could be expected in 2 l. of sea-water.

For analysis, therefore, 20-l. samples were utilized. A known amount of niobium-95 was added to each sample, and the radioactivity of an aliquot assayed. To the remainder was added 175 μgm. of ferric iron. The *p*H was adjusted to 9·9–10·0 by the slow addition of ammonia with constant stirring. After settling, as much as possible of the supernatant was decanted off and the precipitate recovered by filtration. The precipitate was dissolved in a minimum quantity of hydrofluoric acid, transferred to paper, dried thoroughly and chromatographed using ethyl methyl ketone containing 15 per cent v/v of 40 per cent hydrofluoric acid. On the completion of the run the paper was dried and, after exposure to ammonia vapour, sprayed with a 2 per cent solution of tannic acid. Niobium was, under these conditions, detected as a narrow orange-yellow band in the solvent front. Estimation of the amount present was achieved by comparison with standards of varying amounts of niobium, each co-precipitated with 175 μgm. of ferric iron and chromatographed under identical

conditions. After estimation of the amount present in each sample, the radioactivity of the paper strip was assayed to determine the proportion of niobium-95, and hence also of niobium-93, which had been recovered in the analysis. A correction based on this figure could then be applied. The recovery was always better than 50 and usually near 80 per cent. Additional tests were carried out using samples of seawater to which known amounts of niobium-93 had been added.

In water taken in summer from the sea surface at International Hydrographic Station *E*1 (about 40 km. south-west of Plymouth) no niobium was detected by this method if the water was first filtered through Whatman filter paper 542 or through a fine porcelain filter candle. With unfiltered water, however, niobium appeared to be present at a concentration of 0·01–0·02 μgm./l. Bottom water, which may differ widely, has not yet been analysed. In filtered water taken from Plymouth Sound niobium was detected at a concentration of 0·005 μgm./l., while in unfiltered water the concentration reached a level of 0·05–0·1 μgm./l., though in conditions of settled weather with little land water draining into Plymouth Sound the figure was sometimes as low as 0·01 μgm./l.

D. B. Carlisle
L. G. Hummerstone

The Marine Biological Association,
The Laboratory, Citadel Hill,
Plymouth.
Jan. 30.

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Free-Radicals produced in Cigarette Smoke

In attempts to determine a unifying principle of action for the many and varied carcinogenic agents, many workers have assigned an intermediary role to free radicals. The action of ionizing radiation and radiomimetic agents in this respect has been discussed by Brues and Barron[1]. It is stated that many, if not all, carcinogens are compounds capable of forming free radicals which may be stabilized as ions[2]. Oppenheimer *et al.*[3] discussed their possible role in the production of tumours in rodents by implanted films of various high polymers, and suggested, as a requirement for tumour production, the presence of foreign free radicals in a specific area for an extended period.

Primary consideration is normally given to aromatic polycyclic hydrocarbons as active agents in tobacco carcinogenesis. However, in view of the above, it seemed of interest to determine the concentration of free radicals in cigarette smoke. The following series of experiments, which utilized a high-sensitivity electron resonance spectrometer[4], have therefore been carried out. In order to prevent recombination of radicals as much as possible, the smoke was condensed at liquid-oxygen temperatures, and all measurements were made at this temperature.

British-type cigarettes were smoked in a manner simulating the normal human habit. The cigarettes were fixed in a small manifold which was connected to a filter pump so that intermittent drawing was possible. A sealed-off length of ¼-in. diameter tubing led down from the manifold chamber. This tube was immersed in liquid oxygen during smoking. A portion of the smoke was found to condense out in the tube as a pale yellow solid. When about ½ gm. of condensate had been collected, the apparatus was quickly transferred to the electron resonance spectrometer and the tube was inserted into the centre of an H_{014} cavity, surrounded by liquid oxygen. The concentration of radicals in the deep-frozen material was then determined using 100 kc./s. modulation and phase-sensitive detection, so that the free-radical absorption was traced out as a derivative on the pen-recorder. The smoking apparatus was then removed from the spectrometer and the condensate in the tube was warmed to 60° C. for about five minutes so that any active radicals could recombine. The tube and contents were then deep-frozen, re-inserted in the spectrometer and the concentration of radicals again measured. In this way it was possible to distinguish between short-lived, active radicals and those that were stabilized sterically or by resonance[5].

The concentration of radicals obtained in the frozen smoke condensate before warming was of the order of 10^{15} free electrons per gm. It should be noted that this condensate contains large amounts of solid carbon dioxide and ice. On warming, the condensate separated into an aqueous and an organic or tarry phase. No radical concentration at all could be detected in the aqueous phase, and that in the organic phase was reduced by a factor of six approximately. The radicals that could still be detected in the latter were found to be highly stabilized, and no diminution of their concentration was found after several days.

It would therefore appear from these experiments that the tar constituents of cigarette smoke contain about 6×10^{15} free electrons/gm. Some of these radicals, being relatively short-lived, disappear when the condensate is warmed to 60° C. for some minutes. The remainder, however, appear to be very stable and long-lived.

Another set of experiments was carried out with the stable radicals, and their concentration after chemical fractionation was investigated. For this, cigarette smoke was trapped in a series of wash-bottles containing benzene at room temperature. Aliquots of this solution were washed a number of times with (*a*) water, (*b*) 2 *N* sodium hydroxide, (*c*) 2 *N* sulphuric acid, (*d*) 2 *N* sodium hydroxide and then 2 *N* sulphuric acid; (*b*), (*c*) and (*d*) were finally washed with water. The solvent was removed from the various extracted solutions and the free-radical concentrations of the resulting tars compared with a sample of unextracted whole tar by the method outlined above.

A decrease in the initial concentration of free radicals in whole tar was found to follow the various extractions. Washing with water reduced the initial concentration by 20 per cent, with alkali by 50 per cent, with acid by 57 per cent, while washing with alkali followed by acid reduced the concentration by 72 per cent. It would appear from this that a number of different species of free radicals exist in the stable group.

The combined evidence from these experiments suggests that there is sufficient concentration of free radicals in cigarette smoke (when compared with the expected concentrations in the polymer experiments[3]) to act as a carcinogenic agent if such a mechanism is possible. It is interesting to note in this connexion that the concentration of stable free radicals in atmospheric soot is about one hundred times larger than in cigarette smoke. But, as with the polycyclic hydrocarbons[6], adsorption on comparatively larger particles, and further stabilization as a result, are likely to render them inaccessible to the cells.

Most bioassays in tobacco carcinogenesis studies have been carried out using either condensates, which are afterwards taken up in solvents at room temperatures, or tars derived from smoke trapped in organic solvents. It is now clear that such materials are deficient in unstable free radicals initially present in smoke. The free-radical content of cigarette smoke as a parameter in the etiology of lung cancer would therefore seem to be a reasonable possibility.

We are indebted to Dr. P. R. Peacock, director of research, Cancer Research Department, Royal Beatson Memorial Hospital, Glasgow, for reading the manuscript and for helpful advice.

M. J. Lyons

Cancer Research Department,
Royal Beatson Memorial Hospital,
Glasgow.

J. F. Gibson
D. J. E. Ingram

University of Southampton.

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Second Virial Coefficient of Methyl Chloride Vapour

Theoretical considerations, for example, those of Hirschfelder[1], indicate that the virial coefficients higher than the second cannot be large enough to produce, in the isotherms of vapours at reduced temperatures near 0·70, sufficient curvature to be detectable with the experimental techniques available at present. Nevertheless, there are several statements of curved isotherms in the literature. As pointed out previously[2,3], the greatest care is required if errors due to adsorption are to be avoided.

Hamann and Pearse[4] report measurements by a differential compressibility method on methyl chloride and methyl bromide and find that, at the low temperatures, there is an apparent non-linearity of PV with P which they attribute to either higher virial terms or to adsorption. In these experiments the vapour was compressed before an advancing mercury surface. By making reasonable estimates from the data of Bottomley and Reeves[5], it is clear that the non-linearity observed is of the order to be expected from neglect of the adsorption on the surfaces of the apparatus.

That adsorption errors are indeed responsible for this non-linearity is confirmed by experiments which we have carried out recently. The isotherms of methyl chloride have been determined at 22° C. in a differential compressibility apparatus similar to that used previously for xenon[5]. A strictly linear isotherm has been obtained over the pressure-range 750–150 mm. of mercury with eleven experimental PV values at both rising and falling pressures which show a mean deviation of ± 4 in 100,000 from the least-mean-square line. Adsorption has been rendered negligible by two factors. The surface/volume ratio is much lower in our experiments, and the bulbs containing the vapour were made of high-quality silica, which is much less adsorptive than other glasses.

In differential compressibility apparatus in which gas volumes are brought to the same pressure by a mercury manometer, there is a potential error. The mercury surfaces on the two sides of the null manometer are exposed to different gases: if one side contains a vapour near saturation the adsorption on the mercury surface may lower the interfacial tension, and hence the capillary depression, so that apparent equality in the two sides of the manometer does not correspond to equal pressures. This correction increases with increasing pressure of vapour, and is in the sense that equal mercury-levels correspond to the pressure of the vapour being greater than that of the non-adsorbed gas. Hamann and Pearse used a manometer tube of 5·7 mm. bore, giving a depression of about 1 mm., so that a mere 10 per cent change in depression amounts to a considerable uncertainty in pressure. Our null manometer is of 35-mm. bore (depression less than 0·001 mm.), and the associated difficulty of a large dead space is eliminated by a direct measurement of volume at each setting.

The final value for the virial coefficient for methyl chloride from our experiments is 416 ± 1 cm.³/mole at 22° C.

(The late) R. Whytlaw-Gray
C. G. Reeves
G. A. Bottomley

Imperial Chemical Industries, Limited,
Akers Research Laboratories,
Welwyn, Herts.
Feb. 25.

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Promoting the Stable Eutectic Reaction in Magnesium-treated Iron Castings by Vibration during Solidification

By adding magnesium to cast iron in such a way that a few hundredths of a per cent are retained in solution it is possible to suppress the stable eutectic reaction, and in iron so treated the metastable reaction occurs instead, resulting in castings which contain large amounts of iron carbide. Addition (after the magnesium has been dissolved) of about 0·5 per cent of ferro-silicon (containing 80 per cent silicon) favours occurrence of the stable eutectic reaction during subsequent solidification, and spheroidal-graphite particles are so produced[1]. The ferro-silicon alloy inoculates the stable eutectic.

It has now been discovered that the stable eutectic may also be inoculated by vibrating the mould during solidification of the casting. In this way magnesium-treated cast iron, which would normally solidify primarily by the metastable process, is caused to solidify by the stable process, with precipitation of spheroidal graphite.

Castings substantially free from iron carbide have been produced in this way from magnesium-treated metal containing less than 0·2 per cent silicon, cast into graphite moulds. In such a case the combined effects of magnesium, low silicon content, and high rate of solidification normally preclude graphitization dur-

ing solidification, even if ferro-silicon is added as inoculant. Nevertheless, castings in the form of balls 2½ in. in diameter, almost completely free from carbide and containing spheroidal graphite, have been produced under these conditions by vibrating the mould at a frequency of 100 cycles/sec. and with an amplitude of 0·040 in.

Iron castings of this composition and having such a structure, as cast, have never previously been reported. The mechanism whereby this effect is produced is not yet understood.

J. H. Gittus
Development and Research Dept. Laboratory,
Mond Nickel Co., Ltd.,
Wiggin Street,
Birmingham 16.
Feb. 27.

[1] Brit. Pat. 630,070.

Surface Hardening of Non-ferrous Metals by Spark Discharge

An earlier communication[1] from this Laboratory described experiments in which the thermal action of electric sparks was used to simulate the effects of frictional heating on the structure of rubbing steel surfaces. The high local temperatures which characterize rubbing contacts can, in certain circumstances, initiate austenite formation and, since conduction into the bulk metal provides effective quenching of the hot spots, martensite is formed and causes hardening of the surface layer. Similarly the brief but intense heat of an electric spark, struck between an electrode and the steel surface, can harden a small volume of material. If the sparking electrode traverses the surface a hard and wear-resistant skin develops.

There is evidence[1] that during frictional heating nitrogen and carbon can enter the surface from the atmosphere or lubricant and contribute to the hardness of the transformed product. Likewise during spark heating, the nature of the medium which the spark traverses is of importance in determining the constitution and properties of the hardened layer. Thus nitrogen assimilated during air sparking and carbon during sparking in oil can cause intense hardening (~ 900 V.P.N.) even of pure iron. It is, however, well known that, in sparking contacts, material may be transferred from one member to the other. If, therefore, a steel surface is sparked with an electrode of dissimilar metal, this transferred material can be expected to alloy with the steel and may also react with components of the environment to form hard compounds. By appropriate choice of electrode material and sparking medium, the hardness attained might considerably exceed that of quench-hardened steel.

Recent publications[2] reveal that surface hardening by spark discharge has been developed in the U.S.S.R. as a commercial process for improving wear resistance, and many successful applications are claimed. The surface to be treated is traversed with a vibrating electrode which repetitively discharges current from condensers. The sparking potential and capacitance usually fall within the range 50–220 V., 20–350 μF., the electrode having positive polarity to facilitate transfer of material to the cathode, namely, the workpiece surface. Electrodes of sintered tungsten and titanium carbides are commonly employed, and transfer of these carbides plays an important part in conferring wear resistance.

The Russian literature deals exclusively with the spark-hardening of ferrous metals. While, in general, non-ferrous metals cannot be expected to harden intensively by thermal cycling alone, the ability of the spark to transfer, or even generate, hard substances indicates means by which surface-hardening might be effected. Work in this Laboratory has shown that many non-ferrous metals can in fact be surface-hardened if suitable techniques are adopted. Two main principles can be recognized.

(1) Transfer takes place from an electrode of material, such as sintered carbide, which is already hard, the hardness of the alloyed layer produced tending towards that of the electrode material (1,300–1,700 V.P.N. in the case of cobalt-bonded tungsten carbide). Alternatively, the electrode may consist of material which is not initially hard but which hardens in the spark reaction as, for example, an electrode of steel or of a non-ferrous metal of the type to be discussed.

(2) Certain non-ferrous metals, notably those belonging to the fourth and sixth groups of the Periodic Table, will form extremely hard compounds by chemical reaction with elements easily made available in the sparking zone. For example, carbides of great hardness (1,300 V.P.N. to more than 2,000 V.P.N.) can be formed on the surface of titanium, zirconium, molybdenum and tantalum by sparking in a carburizing environment. This environment can be provided by sparking with a carbon electrode, or through the agency of liquid hydrocarbons or powdered graphite in contact with the surface.

The hardened layer produced by sparking is only a few thousandths of an inch in thickness, but, as the curves of Figs. 1 and 2 reveal, this thin skin can confer greatly improved wear resistance. The wear measurements were made by loading a cylinder of the non-ferrous metal against a rotating ring of hardened tool steel, no lubrication being provided. The sparking of nickel with an electrode of sintered tungsten and titanium carbides (Fig. 1) has produced a 600-fold reduction in rate of wear through the transfer of carbide to the nickel surface. Improvements of similar magnitude have been obtained by this technique on copper, brass, titanium and aluminium. The reduced rate of wear of iodide-titanium illustrated in Fig. 2 is the result of a skin of titanium carbide produced by sparking with a titanium electrode in the presence of mineral oil.

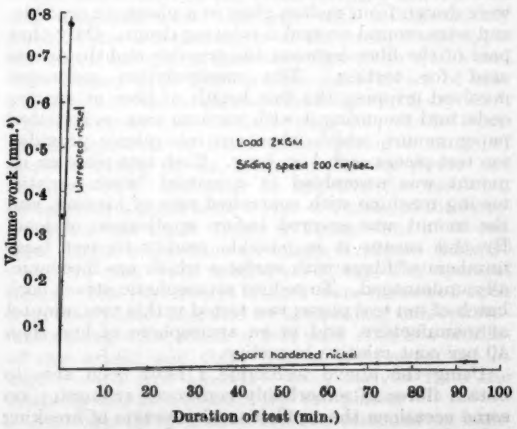

Fig. 1. Change of rate of wear produced by spark-hardening nickel

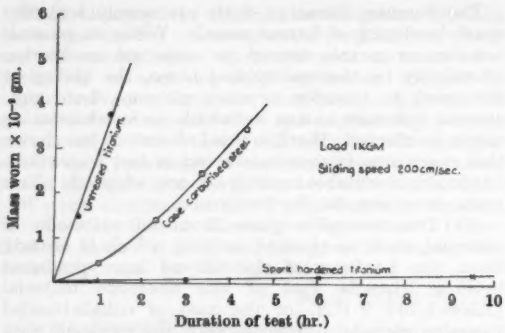

Fig. 2. Change of rate of wear produced by spark-hardening titanium, and comparison with case-carburized steel

For comparison a wear curve for mild steel, case-carburized by conventional means and tested under the same conditions, is also shown in Fig. 2. In these particular rubbing circumstances the spark-hardened titanium is plainly of superior wear-resistance, and it seems likely that spark-treated non-ferrous metals will find applications for wear-resistant parts in engineering practice.

A fuller account of this work will be published in due course.

I am indebted to Dr. W. Hirst for encouragement and advice, and to Mr. P. Watts and Miss B. Green for assistance with the experimental work.

N. C. Welsh

Research Laboratory,
Associated Electrical Industries, Ltd.,
Aldermaston Court,
Berks.
March 5.

[1] Welsh, N. C., *J. App. Phys.*, **28**, 960 (1957).
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Strength of Glass Fibres

Previous workers have reported that the tensile strength of nominally identical glass fibres is very inconsistent, with coefficient of variation between 5 and 25 per cent[1,2]. In an attempt to reduce this variability, I have made and tested 'E' glass fibres under carefully controlled conditions. The fibres were drawn from molten glass in a platinum crucible, and were wound around a rotating drum. Only that part of the fibre between the crucible and drum was used for testing. The manipulation technique involved gripping the free length of fibre at its two ends, and mounting it with vacuum wax on a slotted paper mount, which when cut into pieces provided ten test pieces each 1 in. long. Each test piece on its mount was assembled in a special 'chain-o-matic' testing machine with controlled rate of loading, and the mount was severed before application of load. By this means it is possible readily to test large numbers of fibres with surfaces which are mechanically undamaged. To reduce atmospheric attack each batch of ten test pieces was tested within two minutes of manufacture, and in an atmosphere of less than 40 per cent relative humidity.

Using the above technique I have been able to obtain fibres of remarkably consistent strength; on some occasions the coefficient of variation of breaking stress of ten test pieces has been only 1 per cent.

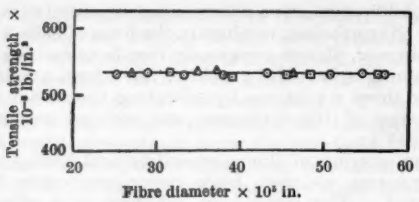

Fig. 1. Temperature of glass in crucible. △, 1,340° C.; ○, 1,300° C.; □, 1,260° C.

Another observation was also made. Over the range for which fibres of uniform diameter can be drawn with my apparatus (2–6 × 10^{-4} in.), the breaking stress is independent of fibre diameter and of the temperature of the glass in the crucible; it is also independent of the rotational speed of the drum. The results are illustrated in Fig. 1. Each point is the mean breaking stress of ten test pieces. Previous workers using different testing techniques have found a very appreciable reduction in breaking stress with increase in diameter for the range shown in Fig. 1.

W. F. Thomas

Engineering Laboratory,
University College,
Cardiff.

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Spiral Pits on Silicon Carbide

The dislocation theory of crystal growth[1] suggests that the crystal growing at low supersaturation in the presence of a single dislocation is not composed of an infinite number of layers stacked on each other as ideally considered, but is a helicoid with the dislocation line as its axis and the point of emergence of the dislocation at the top. The observation of a growth hill in the form of a 'spiral staircase' on a number of crystals reported in recent years[2] has amply substantiated the theoretical predictions. Silicon carbide crystals have afforded evidence[3] of a large variety of spiral growths, for example, monomolecular as well as microscopic, and interaction of spiral growth due to two or more dislocations of same as well as of opposite sign. In some cases, hitherto unobserved, silicon carbide crystals exhibit spirally terraced pits. Fig. 1 shows a phase-contrast micrograph of a spirally terraced pit. It is easy to decide with the fringes of equal chromatic order that this feature is a pit. The step height of this terraced pit as determined from high-dispersion Fizeau fringes corresponds to 27 ± 2 A., which is the repeat distance of this crystal identified by X-rays as 33 *R* (Ramsdell's symbol).

Frank[4] has shown that when growth spreads from an isolated pair of dislocations, respectively right- and left-handed, the terrace line connecting them wraps around and meets itself on the other side: thus forming a short connecting terrace line again and an outward growing closed loop. Such an interaction has been exemplified on silicon carbide[5]. If these two dislocations are cancelled by moving together, as suggested by Mott[6], or by a process of double cancellation, as envisaged by Anderson and Dawson[7], flat-topped crystals would result. Fig. 2 is, however, an example of a flat-bottomed crystal. The

Fig. 1. Spiral pits on silicon carbide. (× 90)

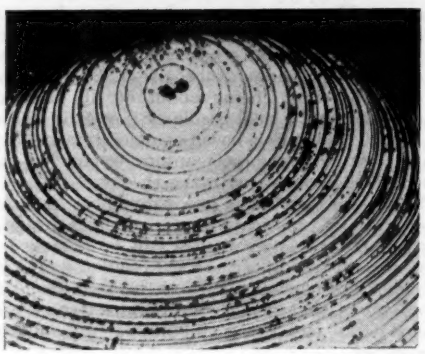

Fig. 2. Spiral pits on silicon carbide. (× 105)

fringes of equal chromatic order passing over the centre of the pit show beyond doubt that it is a pit having a step height of 1050 A.

Such spirally terraced pits are not foreseen as a growth feature on Frank's theory, which envisages spiral pits as a result of dissolution or evaporation. These observations, in conformity with Frank's prediction, suggest that evaporation also takes place in accordance with the dislocation mechanism.

My thanks are due to Prof. S. Tolansky for his kind interest and encouragement and to the Government of India for the award of a Modified Overseas Scholarship, during the tenure of which this work was done in the Physics Department, Royal Holloway College, Englefield Green, Surrey.

V. G. Bhide

Royal Institute of Science,
Bombay 1.
Feb. 8.

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Width of the Green Mercury Line from a 198-Isotope Lamp

In recent years the mercury isotope lamp has been found most useful and convenient for producing fairly bright and extremely sharp emission lines for spectroscopic purposes. Only a fraction of a milligram of mercury-198 is needed for a discharge lamp of this kind, and this isotope can now be produced quite cheaply from gold. This light source has with good reason been proposed for use as a primary standard of wave-length[1].

Recently, Baird and Smith have pointed out[2] that in certain circumstances, depending on the carrier-gas and on the temperature, asymmetrical self-reversal may occur in such lamps, with a disturbing effect on both the line-width and the wave-length. They have also made useful suggestions as to how this self-reversal can be reduced, by the use of molecular carrier gases such as hydrogen and nitrogen[3].

As very little information has been published about the line-widths or the long-term behaviour of such lamps under ordinary laboratory conditions, the following remarks may be useful. The lamp under consideration was bought in 1951 from the General Electric Co., Ltd.[4], being one out of their serial production. It is a water-cooled internal-electrode discharge lamp; its positive-column tube has a length of about 40 mm. and an internal diameter of about 5 mm., with a coaxial water-jacket sealed around it. The lamp contains about 0·1 mgm. of mercury-198, with argon as a carrier-gas under a pressure of about 10 mm. of mercury. It is usually run from a mains transformer at a current of 25 m.amp., striking at about 500 V. and running normally at 200 V. If necessary, it can be operated from a 6-V. or 12-V. battery using a conventional d.c./a.c. converter. Cooling with water at temperatures of 10–20° C., a flow of about 1 litre in 6 min. was found to be quite sufficient. Should no running water be available, as, for example, under certain field conditions, it is quite possible to maintain a water circulation by hand from a small storage vessel. This particular lamp has now worked for several hundred hours over a period of seven years, mainly for calibrating line-widths with interferometers and large spectrographs. It has also been used by three astronomical research expeditions under very primitive field conditions[5].

The line-width for the green mercury line 5461 A. was measured some time ago with a high-quality Fabry–Perot interferometer of the multicoated type. Its crystalline quartz flats were figured to 1/40 λ and were coated with four quarter-wave layers of zinc sulphide and three quarter-wave layers of cryolite[6]. The reflectivity was at least 95 per cent; the 0·75-cm. spacer consisted of fused silica, giving a range of about 0·170 A. in air, with a resolving power not far from 10^6. In order to improve the resolving power, only a small area, 5 mm. × 7 mm., of the interferometer was used. Using a 'Tessar' lens of 50-cm. focal length to produce an image, exposure times of about 10 min. were needed on Kodak *I–G* spectral plates. The first twelve fringes were measured both by a micrometer and also by a recording microphotometer using a slit width of 0·01 mm. The line profiles of the second and third fringes are reproduced in Fig. 1 on a true intensity scale, derived from the intensity marks available for the plates.

Although these profiles are not intended as high-precision photometric data, they may give useful

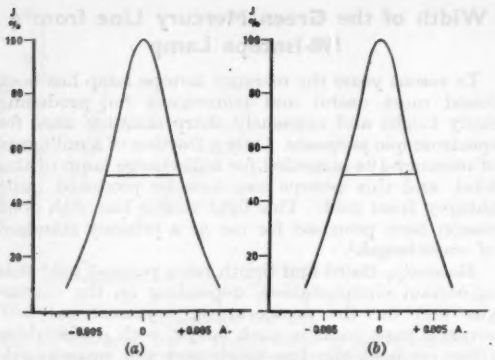

Fig. 1. Width of the green line of a mercury-198 lamp determined from the second (*a*) and third (*b*) fringes in a Fabry–Perot interferometer

indications of what to expect with a lamp of this kind under normal working conditions. No indication of self-reversal can be detected. However, the thickness of the discharge column was only about 5 mm. (giving quite sufficient light for most purposes) and water-cooling was used, so that the conditions were different from those reported in ref. 2. The half-width was found photometrically to be about 0·006–0·007 A., while the widths of the fringes measured by micrometer were found to be slightly smaller. Such a width is scarcely attainable so conveniently from any other light-source, and it is sufficiently small for investigations even with very powerful spectrographs. Moreover, this may not be the minimum width attainable since the values found here are restricted by the resolving power of the interferometer used, for which a longer spacer was not available. The real line-widths are probably very near the Doppler widths which, at room temperature, should be about 0·0055 A.

H. von Klüber

The Observatories,
Madingley Road,
Cambridge.
Feb. 12.

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A New Microwave Mixer

The Hall effect in semi-conductors has been used at microwave frequencies for the measurement of power. It has recently been demonstrated that a simple modification to the power-measuring equipment leads to a mixer. The principle of operation of this mixer is straightforward. A local oscillator is used for establishing a field in a resonant cavity and a small piece of semi-conductor is placed at a point in this cavity where there is maximum magnetic field and no electric field. The semi-conductor is coupled to a second wave-guide carrying a microwave signal, the coupling being effected by a probe which causes a current to flow in the semi-conductor; the direction of the current is selected to be at right angles to the local oscillator magnetic field. Since the signal is coupled to the semi-conductor by electric field, whereas the local oscillator field at the semi-conductor is magnetic, there is no interaction between the local oscillator and signal channels. A Hall electromotive force is established, the instantaneous value of which is proportional to the product of the local oscillator magnetic field and the signal current. This electromotive force has therefore components of frequencies equal to the sum of the local oscillator and signal frequencies and to their difference. The latter signal can be amplified as in a normal mixer.

This form of mixer has been examined with a signal of approximately 8 cm. wave-length, giving an output of 60 Mc./s., and it has been confirmed that the mixing operation described above does take place. A simplified theoretical analysis shows that the conversion efficiency of the mixer is independent of the semi-conductor dimensions and is directly proportional to both the local oscillator power and to the square of the electron mobility in the semi-conductor, assuming that this is an n-type material. The output power from the mixer is proportional to the signal power provided that the signal power dissipated in the semi-conductor does not cause an appreciable temperature rise. The conversion loss is rather high, being about 60 db. for indium antimonide with a local oscillator power of 100 watts at 8 cm. This figure is based on calculations; experimental results using germanium appear to be in reasonable agreement with the theory.

The present conversion loss is much too high for the mixer to be of practical value in receiver design, but it is hoped that lower figures can be achieved with more efficient design of the local oscillator cavity and for higher frequencies. The main interest in the mixer at present is that it can be developed to provide a method for measuring mobilities at microwave frequencies.

H. M. Barlow
J. Brown
K. V. Gopala Krishna

Dept. of Electrical Engineering,
University College,
London, W.C.1.
Jan. 23.

Germanium Enrichment in Lignites from the Lower Lias of Dorset

Certain carbonaceous inclusions from the United States are exceptionally rich in germanium[1,2]; hitherto no such enrichment has been reported from the British Isles. A number of lignite specimens recently collected from the Lower Lias of Dorset have now been shown to have similar concentrations of germanium to those of the American samples.

The Lower Lias of Dorset consists of a series of marine shales and marls and subsidiary limestones attaining a thickness of about 170 m. Details of the succession, which is well exposed on the coast around Lyme Regis and Charmouth, are summarized by Arkell[3]. Scattered throughout these beds are fragments of lignite. The lignite is more common at certain horizons, for example, 'Grey Ledge' at the top of the Blue Lias and the 'Woodstone' of the Black Ven Marls. It is never easily detected in the

cliff section, but may be found quite readily on the foreshore. Specimens of lignite embedded in several types of rock were collected from a 5-mile stretch of the coast centred about Lyme Regis. These specimens were mostly a few cm. long and varied in thickness from 4 to less than 1 cm.

The lignites may be grouped into two main varieties termed 'wood-like' lignite and 'jet'. The former is brown and fibrous and is frequently enveloped and intersected by veins of calcite or barite. Wood-like lignite is found in the form of rafts lying parallel to the bedding plane, and as cylindrical 'branches' enclosed in boulders. Occasional giant specimens of up to 3 m. long have been reported (Lang, W. D., private communication). The jet is black and possesses a vitreous lustre on freshly fractured surfaces, which are often conchoidal. Calcite and barite veins are generally less conspicuous. Jet is sometimes found associated with larger bodies of wood-like lignite; but in general, small, isolated samples of jet occur as lenticles parallel to the bedding plane. Microscopic examination of thin sections has shown that the wood-like lignite is composed of thick-walled tracheid cells infilled by calcite. In most specimens of jet, on the other hand, cell structure is completely obliterated, although in some cases partly preserved bordered pits and thin-walled cells infilled by red-brown structureless carbonaceous matter have been observed.

The germanium in the lignites has been determined by spectrographic analysis of their ashes. The ash contents of the lignites varied from about 5 per cent for some of the jet specimens up to 90 per cent for the highly mineralized samples. In 10 of the 29 samples examined, germanium concentrations in the ash exceeded 1 per cent, while concentrations approaching 1 per cent in the whole lignite were found for several samples. The mean concentration for the lignites is about 300 times the mean value for British coals. The results are summarized in Table 1.

Table 1

	Germanium (per cent)	
	Ash	Lignite
Maximum concentration	8·4	0·93
Minimum concentration	0·026	0·024
Mean concentration	1·48	0·18

The jet usually contained higher concentrations of germanium than the wood-like lignite. However, when the concentrations were expressed in terms of the carbonaceous portion of the lignite, the mean values for jet and for wood-like lignite were found to be not significantly different. In contrast to the high concentrations in lignites, the germanium contents of the parent rocks were of the order of a few p.p.m. only. The mean values for shale, marl, limestone and pyrite were 1·7, 2·5, 3·9 and 2·4 p.p.m. respectively. No correlation was found between the germanium contents of the lignites and those of their parent rocks.

There is little doubt that the lignites originated as coniferous driftwood which sank to the bottom of the Liassic sea in a water-logged condition. The wood probably became buried before it reached an advanced stage of decay. The results of the microscopic examination show that the differences between the two varieties of lignite developed during diagenesis. Thus driftwood enveloped in limestone became mineralized by the crystallization of calcite within the tracheid cells and gave rise to wood-like lignite. In marl and shale, however, calcite mineralization was limited and the cell structure progressively replaced by colloidal organic matter, the eventual product being jet.

It is unlikely that the wood from which the lignite originated was highly germaniferous. The element was probably introduced subsequent to the burial of the driftwood. If the enveloping sediments had access to a suitable reservoir of germanium, the element could be brought into contact with the organic material by means of circulating solutions and accordingly adsorbed by the carbon. The observation that both varieties of lignite have similar germanium concentrations relative to carbonaceous matter supports the idea that germanium is associated with this portion of the lignite. It is probable that the small size of the lignite inclusions was conducive to their germanium enrichment. Thin seams of carbonaceous material have been reported by several workers[2,4–6] to be abundant in certain trace elements. It was found that some of the Lyme Regis lignites also have revealed exceptionally high contents of other trace elements in addition to germanium; namely, vanadium and titanium. Since these latter two elements, like germanium, are likely to occur as anions in ground solutions, their abundance in lignite may be partly attributable to preferential adsorption of negative ions by the carbonaceous material.

A. Hallam

Sedgwick Museum,
Cambridge.

K. W. Payne

Fuel Research Station,
Greenwich, London, S.E.10.

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Twining of the Hop (*Humulus lupulus* L.)

Casual observations made by me on the twining of the shoots of the hop suggested that in the first phase of growth (in which the stem extends rapidly and the laterals remain suppressed) the angle made by the gyres of the helix with the horizontal varied with the diameter of the support.

In 1957, experiments were made upon the shoots arising from four sets of Fuggle *N*, a cultivated variety, to determine whether there was a strict relationship between these two quantities. The main crop of shoots appearing above ground in early spring was made to climb vertical rods of different diameters to a height of about 6 ft. Four of the rods consisted of three equal sections of different diameters, two with the broadest portion at the base and two with the narrowest. The remainder of the rods were uniform. Above the rods the shoots were allowed to tangle together and their climbing behaviour was not studied. Only in one shoot was there an outgrowth of the lateral buds, and this was confined to the upper portion of the rod.

The shoots, which ascended the rods very rapidly once twining began, formed almost uniform helices, as the small range in the size of the angle formed

Table 1

Radius of support (1 unit = 1/16 in.)	No. of observations	α Range (deg.)	α Mean (deg.)
2	5	69·5–74·0	70·8
3	6	64·5–72·0	68·2
3 (Late stem)	4	61·0–67·5	63·9
4	8	63·5–71·0	66·8
5	9	60·0–67·0	62·1
8	3	49·5–57·0	54·3
8	3	56·5–57·5	57·2
16	1	42·0	42·0
16 (Lateral buds growing out)	1	52·0	52·0
24	1	20·0	20·0

with the horizontal (α) in a vertical series of readings along one rod will show (Table 1). Each stem can therefore be considered as describing a simple helix on a circular cylinder cutting the generators at a constant angle. The radius of curvature of such a helix (R) is related to the radius of the cylinder (a) according to the equation

$$R = a\sec^2\alpha$$

where $(90° - \alpha)$ is the angle with the generators and α the angle made by the tangent to the helix with the plane perpendicular to the axis of the cylinder[1].

The fact that the steepness with which the stem of the hop twines diminishes with increasing diameter of the support suggests that the radius of curvature of its helix may remain constant. We should then expect a straight-line relationship between the radius of the support and the square of the cosine of the angle at which the stem climbs. This line should not pass through the origin, but cut the a-axis at a negative value equal to the radius of the shoot, since we must consider the helix as being described by the longitudinal axis of the shoot upon the surface of a cylinder the radius of which extends to this axis. The results of eight series of observations show that the expected proportionality does in fact exist (Fig. 1). Owing to shoots catching and transferring themselves to adjacent rods in the experiment, only one grew up the whole length of one of the rods of varying diameter. The values given by it fall into alignment with those of shoots climbing uniform rods or portions of rods. A line fitted by eye to the points cuts the co-ordinate axis 1·2 units below the abscissa, a value of the same order as half the diameter of a hop stem.

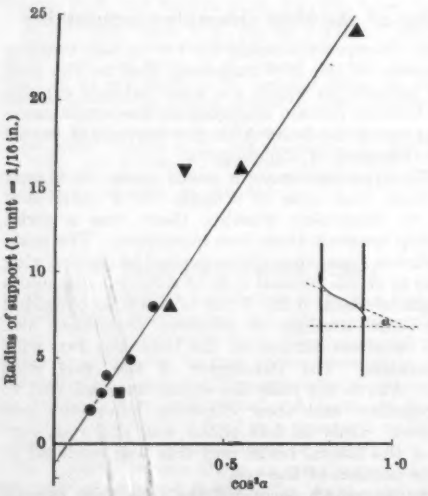

Fig. 1. ▲, Values given by one stem climbing a rod of sections of different diameter; ▼, a stem in which the lateral buds had grown out; ■, a stem ascending after the first flush

These observations agree with Darwin's contention that the twining of the hop is brought about by a wave of growth travelling around the shoot in the extending region[2]. It follows that the intensity of this wave, which will determine the curvature of the helix, is independent of the diameter of the support and consequently must be a property of the stem. It is difficult to decide whether or not the steepness at which the stem twines affects the position of the apex in relation to gravitation, since the upper 6 in. or so of the stem show constant and wide circumnutation, but it can be said that any difference is slight. It is conceivable, therefore, that the gravitational stimuli received by the apex are not affected by the position assumed by the lower regions. A constant curvature in the region of most pronounced internodal extension, where alone the stem first applies itself closely to the support, could then be brought about entirely by an area of vigorous auxin production revolving around the apex as it grows. A comparison of the parenchymatous cells of the cortex on the convex and concave sides of a short median section taken in the plane of the curvature from a stem climbing a support $\frac{3}{8}$ in. in diameter showed that the ratio of their lengths was of the same order as would be expected were the curvature attributable entirely to differences in cell elongation (Table 2). This is in conformity with the above hypothesis, but it could also result from a lateral displacement of auxin, such as may occur in haptotropism. Haptotropism by itself, however, could not account for the twining, nor for the constant curvature of the helix.

Table 2. Twenty-two Cells taken from Each Side

	Mean length (μ)	Ratio Observed	Ratio Expected
Convex side	27·7	1·15	1·13
Concave side	24·9		

Only one stem continued to twine around a support three inches in diameter. Others came away from the support after beginning to twine, suggesting that as the radius of the support approached the radius of curvature of the helix the twining system became unstable. One record from the upper part of a stem which had entered the phase of growth in which the laterals grow out is included in Fig. 1. The outgrowth of laterals appears to be accompanied by a diminution in the curvature of the main axis. One of the weaker shoots arising later was also included in the experiment, and the mean curvature of its helix is seen from the results to have been greater than that of a shoot of the first flush.

Further experiments on this and other twining plants are planned.

P. R. Bell

Botany Dept.,
University College,
London, W.C.1.
Jan. 6.

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Relationship between *Merulius lacrymans* and *M. himantioides*

THE relationship between the brown-spored species under *Merulius* is not certainly known. The two species, *M. lacrymans* (Wulf.) Fr. and *M. himantioides* Fr., are regarded by Cooke[1] as morphologically alike but distinguishable on the basis of physiological activity and habitat. He therefore considers them as varieties under the same species. He has, however, stated that "more than one species may be indicated if unsuccessful monospore culture pairings are used as indicators of specific barriers". This criterion is used for studying the relationship between *M. lacrymans* and *M. himantioides*.

M. lacrymans was collected from wood of *Pinus sylvestris* in buildings in Denmark at Kibaek, Jutland and at Copenhagen. The latter collection was flown over to Dehra Dun for study. In both our Institutes, the fungus was brought to polyspore and monospore cultures. The spores germinated within 12–15 days after they were planted on 2·5 per cent malt agar at *p*H 5·0 at 18° C. During germination, the spore usually put out a vesicle which finally produced a germ tube. Clamp connexions, which were common in the polysporous mycelium of *M. lacrymans*, were absent in the monosporous mycelium of the fungus, in the hyphæ of which simple septa were present. When two compatible monospore mycelia were paired, clamps developed on the mating hyphæ. In incompatible matings, clamps did not develop. By pairing the monospore mycelia in all possible combinations, they were found to fall into four sexual groups. *M. lacrymans* was thus found to be heterothallic and tetrapolar.

M. himantioides was collected from the open forests in the Western Himalayas (above 6,000 ft.) in India growing on bark of conifers (*Cedrus deodara* and *Picea morinda*). In Denmark, the fungus was collected from floor boards of pine (*P. sylvestris*) in a house at Hundested, North Sealand. Polyspore and monospore cultures of the fungus were obtained from fruit bodies collected from both localities. Germination of spores occurred freely within two days on 2·5 per cent malt agar at *p*H 5·0 at 18° C. On germination, the spore put out a germ tube directly. In this it differed from *M. lacrymans*, where the spore usually germinates by production of a vesicle. In *M. himantioides*, the single-spore cultures did not possess clamps in the hyphæ, which occurred only in polyspore cultures. The spores fell into four sexual groups, and the fungus is heterothallic and tetrapolar.

Crosses were then made between the monospore cultures of *M. lacrymans* and *M. himantioides* by pairing the four sexual strains of the former with those of the latter in all possible combinations. In this test, the Jutland and Copenhagen collections of *M. lacrymans* were paired respectively with North Sealand and Indian collections of *M. himantioides*. Clamps did not develop in any of the pairings, proving that the two fungi are mutually intersterile.

M. lacrymans differs from *M. himantioides* in habitat, the former being usually domestic and the latter wild. The two fungi also differ in the morphology of the sporophore and in culture, particularly in the texture and colour of the mat and formation of profuse liquid drops in *M. himantioides* and their absence in *M. lacrymans*. In culture the optimum growth of *M. lacrymans* occurs at about 18° C., while with *M. himantioides* it is at about 28° C., at which *M. lacrymans* ceases to grow. These differences are believed to be sufficiently diagnostic for identifying the two fungi as distinct species, and this is confirmed by genetic studies as reported above. A detailed account of this work will be published later.

L. HARMSEN

Technological Institute,
Copenhagen, Denmark.

B. K. BAKSHI
T. G. CHOUDHURY

Forest Research Institute,
Dehra Dun, India.
Jan. 13.

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Occurrence of Spermatophores in the Genus *Dolops* (Crustacea : Branchiura)

ACCORDING to all those who have defined the group, one of the diagnostic characteristics of the Branchiura is the absence of spermatophores. Indeed, the mating habits of members of the genus *Argulus* are sufficiently well known to enable it to be stated that here no such structures are involved in sperm transfer, and recent unpublished observations on various species of the genus *Chonopeltis* (some as yet undescribed) indicate that here also no such structures are found. On the other hand, the existence of spermatophores in the genus *Dolops* has recently been established.

These structures were first observed in Africa during the course of an examination of specimens of *Dolops ranarum* (Stuhlmann), which is the only known African representative of an essentially South American genus. Later, when an opportunity was taken to examine the rather small collection of South American species of *Dolops* in the British Museum (Natural History), a single female of *D. geayi* (Bouvier) was found to be carrying a spermatophore, thus suggesting that the employment of these structures may be a regular feature of the reproductive process throughout the genus.

The following remarks apply particularly to *D. ranarum*; but the spermatophore of *D. geayi* appears to be essentially similar to that of its African relative.

Spermatophores, which bear a most striking resemblance in form, colour and lustre to pearls, are attached singly in the mid-ventral line of the female at the base of, and just behind, the fourth pair of legs. Their size appears to vary according to the size of the male which produced them, and possibly according to other and, as yet, unknown factors. The length of the longest axis of these subspherical structures may be as much as 560μ.

Transference of spermatophores from male to female has been observed, and is a relatively simple process, as might reasonably have been inferred from the almost complete lack of accessory copulatory organs in *D. ranarum*, which contrasts strongly with the presence of extremely complex organs in the males of all known species of *Argulus* and *Chonopeltis*.

While the purpose of this communication is essentially to announce the discovery of spermatophores, a note of caution must be sounded to those who would cite their existence as evidence of a close relationship of this taxonomically enigmatical group to the Copepoda. It is true that the possession of spermatophores by *Dolops* suggests that the Branchiura is quite distinct from the Branchiopoda with which some would group it. On the other hand, however, spermatophore formation need not necessarily represent the

retention of a characteristic exhibited by a possible common ancestor of the Copepoda and Branchiura. It could equally well be a device which has arisen independently in the genus *Dolops* in order to facilitate successful sperm transfer in the absence, in some species at least, of the complex accessory copulatory organs found in allied genera. Preliminary observations indicate that spermatophore formation in *Dolops* involves processes which are unknown in any of the Copepoda. It is hoped to pursue these studies further in due course.

Ironically, although spermatophores are reported here for the first time, they were in fact unwittingly mentioned more than sixty years ago by Stuhlmann[1], who described *D. ranarum*, and reported that "oft sieht man an der Geschlechtsöffnung des ♀ ein rundes, weisses Ei". What Stuhlmann took to be an egg was in fact a spermatophore.

G. Fryer

East African Fisheries
Research Organization,
P.O. Box 343,
Jinja, Uganda.

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Retinal Pigments of a Labrid Fish

The distribution of visual pigments in aquatic vertebrates has been assumed to follow this pattern[1]: marine fishes possess rhodopsin ($\lambda_{max.}$ 500 mμ), based on retinene$_1$, and freshwater fishes possess porphyropsin ($\lambda_{max.}$ 522 mμ), based on retinene$_2$. Since the report by Wald[1] that labrid fishes have porphyropsin, the members of this family of marine teleosts have been regarded as exceptions to the general picture of visual pigment distribution. It should be made clear, however, that Wald did not study the visual pigment itself in the Atlantic species, *Tautoga onitis* and *Tautogolabrus adspersus*, which he examined, but based his conclusions on an analysis of the retinal vitamin A. Confirmation was reported by Kampa[2] for two unspecified corid (labrid) fishes in the Caribbean. She apparently studied the visual pigment, retinene and vitamin A, but only summarized her findings and has not published the full results. More recently, in a brief abstract[3], Wald has stated again that *Tautoga* possesses porphyropsin.

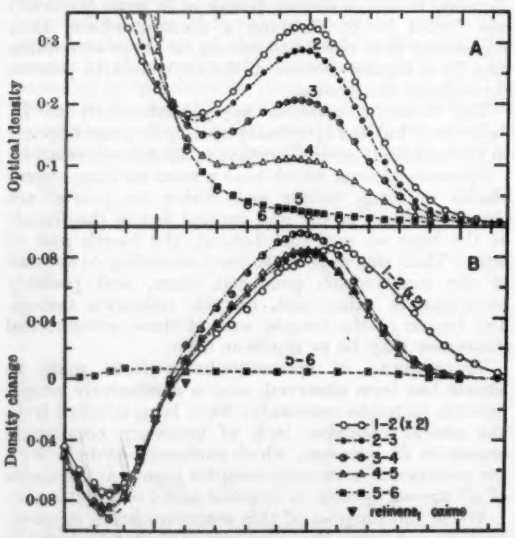

Fig. 1. *A*, Partial bleaching experiment. Curve 1, absorption of unbleached extract; curve 2, after 80-min. exposure to 650 mμ light; curve 3, after 20-min. exposure to 605 mμ light; curve 4, after 45-min. further exposure to 605 mμ light; curve 5, after 75-min. exposure to 590 mμ light; curve 6, after 10-min. exposure to white light. *B*, Difference spectra of partial bleaching experiment. Curve 1–2 (drawn to × 2 scale) is the result of the 650 mμ bleach, 2–3 and 3–4 the 605-mμ bleaches, 4–5 the 590-mμ bleach, and 5–6 the white light bleach. The inverted triangles are spectral densities of a digitonin solution (*p*H 8·3) of retinene$_1$ oxime scaled for comparison with curve 1–2

The sheep-head, *Pimelometopon pulchrum* (Ayres), is a labrid of the eastern Pacific. Over the last 30 months, four digitonin extracts of the retinæ of this species (gratitude is expressed to Marineland of the Pacific for the specimens used in this study) have been prepared and analysed by methods described elsewhere[4]. The results have been consistently the same: the chief photosensitive retinal pigment of the sheep-head is a retinene$_1$ pigment with $\lambda_{max.}$ 497 mμ. In addition there is a small amount of another retinene$_1$ pigment with $\lambda_{max.}$ 520 mμ. These two photolabile components were present in the extracts in the ratio 85 : 15. This mixture was disclosed by partial bleaching experiments without hydroxylamine (not figured) and with it (Fig. 1). Exposure to deep red light selectively removed the red-sensitive component (curve 1–2). Further exposure to non-isomerizing light of shorter wave-lengths then bleached the main photolabile component (curves 2–3, 3–4, 4–5).

The product of bleaching of both components is characteristic of retinene$_1$ pigments. In Fig. 1*B* the absorption spectrum (inverted triangles) of retinene$_1$ oxime (prepared from crystalline all-trans retinene$_1$) is plotted for comparison with the bleaching product of the red-sensitive component. In experiments without hydroxylamine the spectral position of the alkaline indicator yellow also suggested that retinene$_1$ is the chromophore. Neither light-sensitive component in the sheep-head retina, therefore, can be termed a porphyropsin.

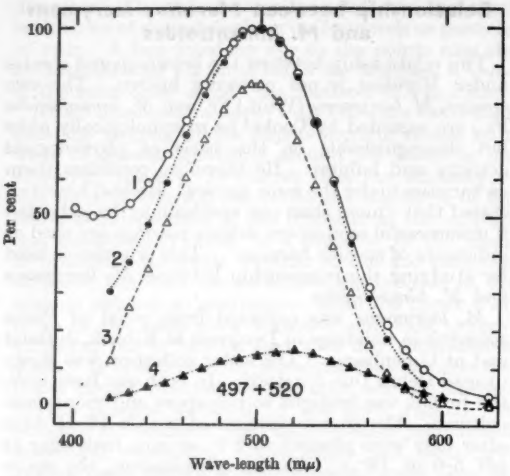

Fig. 2. Curve 1, absorption of unbleached extract; curve 2, constructed from Dartnall's nomogram, assuming $\lambda_{max.}$ 500 mμ; curve 3, difference spectrum of red-insensitive component; curve 4, difference spectrum of red-sensitive component. Curves 3 and 4 scaled so as to approximate in sum the total difference spectrum

Comparison of the absorption of the unbleached extract (Fig. 2, curve 1) and the nomogram construct[5]

(curve 2) for a visual pigment with $\lambda_{max.}$ 500 mμ shows that the nomogram curve is not broad enough to match the retinal extract. This suggests a mixture of components, confirming the result obtained in bleaching experiments. The hydroxylamine difference spectra (curves 3, 4) of these pigments are shown in about the proportion that they are present in retinal extracts.

It is clear that these results do not confirm the general statement of Wald[1] that the Labridae possess porphyropsin. In the sheep-head, at least, there are two pigments, one very similar to lamprey visual purple[6], the other to the visual pigments of geckos[7]. Whether the red-sensitive component of *Pimelometopon* is a cone pigment or a secondary rod pigment cannot be decided from the present observations. Unlike chicken iodopsin[8], the red-sensitive pigment of the sheep-head is stable under alkaline conditions and in the presence of hydroxylamine. It would be very desirable to re-examine the Atlantic labrid fishes to determine whether they really do have porphyropsin and whether this marine family is split into two groups, those with retinene$_1$ photopigments, and those with retinene$_2$ pigments.

FREDERICK W. MUNZ

Dept. of Zoology,
University of California,
Los Angeles, 24.
Jan. 14.

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Effects of Ultra-Violet Radiation on Oysters

IT seemed of value to examine the influence of ultra-violet light upon the rate of cleavage of artificially fertilized eggs of *Crassostrea angulata* L., the larvæ of *Ostrea edulis* L., as well as their adults. The oysters were collected in the summer of 1956 from their natural beds in south Brittany. The experiments were undertaken partly in the Auray Bacteriological Laboratory, and partly in the Arago Laboratory at Banyuls-sur-Mer. A wavelength of 3600 A. from a quartz mercury arc was used.

The gametes and the fertilized eggs of *C. angulata* were irradiated with graded doses up to 30 min., with the ultra-violet source 50 cm. above the water level. The sperms were found to be more resistant than were the eggs. After doses longer than 5 min., there was a pronounced reduction in the rate of cleavage; when the controls had reached the second cleavage stage, some of the eggs irradiated for 10 min. had not completed the first stage. Later, when 100 per cent of the controls had developed into ciliated trochophores, some of the irradiated eggs were still in the first, second and third cleavage stages and only 5 per cent had developed into free swimming blastulæ. With still stronger doses of 20–30 min., 10 per cent of the eggs developed into balls of motile cells, and 90 per cent remained with the germinal vesicle intact.

Normally, the newly hatched larvæ of *O. edulis* manifest positive phototropism and negative geotropism. When irradiated for 5–7 min. in a container 1 m. deep, with the ultra-violet source 35–125 cm. above the water surface, they showed a tendency to occupy the lower levels in the aquarium and finally to stop swimming freely and to settle down near the bottom with their shells almost closed. Evidently, it was a temporary tropistic response to avoid injury, as many were noticed, later, to regain their activity and to swim freely again. The percentage of larvæ recovered and the time of recovery depend largely upon the strength of the dose.

An exposure of 15 min. from a source at 35 cm. above the surface of water only 20 cm. deep was lethal. The ultra-violet effect was, however, eliminated when, in a new experiment, a glass plate was placed between the larvæ and the ultra-violet source, showing that the larval shell was not adequate protection against strong doses.

The adult *C. angulata* and *O. edulis* were found to resist strong doses of 30–60 min. with the source 35–50 cm. above the surface. All the oysters survived normally for the next two months, and some even showed a slight growth. Many of the parasites which happened to live on their shells were killed by the irradiation.

The radiosensitivity of many planktonic organisms, including some oyster enemies, was found to vary widely in the different forms. While worms like *Polydora*, bacterians and some fungi were highly susceptible, crustacean larvæ and copepods proved to be less sensitive.

In brief, the main conclusions are: 1, the cleavage of artificially fertilized eggs as well as the development of later stages of *C. angulata* is considerably retarded after irradiation; 2, the results of irradiating *O. edulis* larvæ help to explain—in the light of studies on solar radiation and its transmission through air and water—the variations noticed every year in the density of oyster spat setting at different levels on natural and artificial collectors; 3, the resistance of the animal, regardless of its size, depends upon the nature of its outer surface, its thickness, and the strength of the dose; 4, a great progress in artificial propagation of oyster culture would be achieved by discovering some control method involving the use of ultra-violet doses not harmful to the oysters, their larvæ, or feeding organisms, but destructive to the enemies which compete with them for food and space.

Although the practical application of such methods to natural shellfish grounds would be very difficult, I think they might be used on the small isolated bodies of water used for rearing oyster larvæ artificially and for growing their food cultures.

My special thanks are due to Prof. G. Petit, director of the Arago Laboratory, and to M. L. Marteil, chief of the Bacteriological Laboratory at Auray, for the many courtesies extended to me during my work in France.

I. A. ABOUL-ELA

Oceanographic Institute,
University of Cairo,
Al-Ghardaqa, Red Sea,
Egypt.
Jan. 8.

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Labelling of Bull Semen with Phosphorus-32 *in vivo*

Recent work has indicated that when rams are injected intravenously with labelled phosphate and serial samples of semen collected, the various phosphorus components of the semen appear with maximal radioactivity in a definite time sequence[1]. In this communication these experiments have been extended to a bull, both with the view of obtaining information about various physiological processes in its reproductive tract and also for acquiring labelled sperm for other experimental purposes.

A Shorthorn bull (780 kgm.) was injected intravenously with 14 ml. isotopic saline containing 25 mc. labelled phosphate through a cannula inserted into the jugular vein. Semen samples were collected twice a week using an artificial vagina. The sperm were examined throughout the investigation for motility, morphological appearance and density, and no indication of any change became apparent. This showed that the testes cannot have suffered any gross radiological damage due to the administration of the isotope. The sperm and seminal plasma were then separated by centrifuging and the following fractions isolated and assayed for radioactivity and phosphorus: sperm acid-soluble phosphorus, phospholipids, deoxyribonucleic acid and residual phosphorus (Schmidt and Thannhauser[2], phosphoprotein + ribonucleic acid); seminal plasma glycerylphosphorylcholine and total phosphorus. The methods used for fractionation and analysis have been described previously[1]. However, due to the presence of considerable mucoprotein in bull seminal plasma compared with that of the ram, it was necessary to modify the procedure for the isolation of glycerylphosphorylcholine as follows. The seminal plasma (3–4 ml.) was treated with 7 ml. ethanol, centrifuged and the supernatant taken to dryness *in vacuo*. The residue was extracted with 10 ml. ethanol and the ethanol-soluble substances then partitioned between water, chloroform, butan-2-ol and chromatographed as described for the ram.

In Fig. 1 is illustrated the pattern of activity appearing in ejaculates collected over a period of 70 days. The seminal plasma glycerylphosphorylcholine acquired maximal activity in samples obtained 11 and 14 days after isotope injection and then its radioactivity slowly declined. The peak of its activity arrived before the activities of any of the sperm components appeared with maximal activity which is consistent with observations made upon the ram, and the conclusion that the source of semen glycerylphosphorylcholine is largely in the epididymides[1,3]. It is interesting that the specific radioactivity of the seminal plasma total phosphorus fraction closely followed that of the glycerylphosphorylcholine. Although this phosphodiester would be the major component in the seminal plasma phosphorus fraction, it is surprising that there is no evidence of an ejaculation of highly active phosphate immediately after the isotope administration or contamination of the semen with highly active urine phosphate. This is possibly because the injected labelled phosphate rapidly disappears from the blood stream and that equilibrium conditions are established long before the first semen sample was collected, that is, 4 days after the injection.

The sperm phospholipid, residual phosphorus and acid-soluble phosphorus in the ejaculates reached a maximum initial labelling at 21, 18, and 25 days respectively. The acid-soluble phosphorus in the sperm shows some evidence of an exchange with the phosphorus in seminal plasma as there is a distinct kink in the curve at the time when seminal plasma phosphorus shows its maximum specific radioactivity. This probably occurs after ejaculation; Bishop and Weinstock[4] have found, for example, that bull spermatozoa when suspended in saline containing labelled phosphate rapidly acquire radioactivity in their acid-soluble phosphorus fraction.

The main peak in the specific radioactivity time-curve of the sperm deoxyribonucleic acid phosphorus reaches a maximum 60 days after the injection, which compares with a time of 50–52 days found for the ram. Recently, H. H. Koefoed-Johnsen (personal communication), in similar experiments

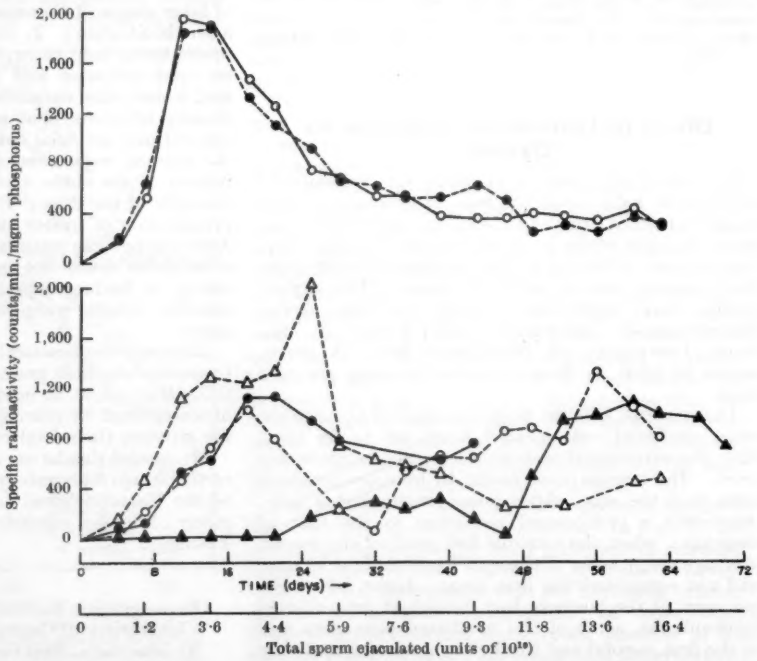

Fig. 1. The appearance of labelled phosphorus components in samples of semen collected from a bull injected with radioactive inorganic phosphate. The abscissa represents the time in days after the injection and on a lower scale is given the total number of sperm ejaculated after the administration of isotope. Upper curves, seminal plasma. ○—○, glycerylphosphorylcholine phosphorus; ●---●, total phosphorus. Lower curves, sperm. ●—●, lipid phosphorus; △---△, acid-soluble phosphorus; ▲—▲, deoxyribonucleic acid phosphorus; ○---○, residual phosphorus

which are as yet unpublished, found that in a bull dosed with labelled phosphate it required some 62 days for the sperm deoxyribonucleic acid to be ejaculated with maximal activity: a value which is in good agreement with the present results. The sperm deoxyribonucleic acid possesses some low activity before the appearance of the main activity peak; such a phenomenon did not occur in the ram and it is consequently difficult to assess its significance from an experiment on a single animal. In the ram it was suggested that the difference between the times of ejaculation of the main sperm phospholipid and deoxyribonucleic acid peaks was due to the fact that while the former would be added or turned over up to the end of spermatogenesis, no new deoxyribonucleic acid would be formed after the mitotic divisions forming the primary spermatocyte. If this explanation is correct, this would mean that in the present experiment the average time for the primary spermatocytes to be converted into the finished spermatozoa would be 39 days.

Bronsch and Leidl[5] have recently found that in bulls given labelled phosphate intramuscularly maximum activity was ejaculated in the semen 14 days after its administration: all the activity being found in the seminal plasma and none in the sperm. The present experiment agrees with these observations in that the seminal plasma total phosphorus reaches peak activity in the 11–14-day period after isotope administration, but shows in addition that at this time a small but significant part of the labelling is present in the sperm and cannot be removed from it by saline washing.

I am indebted to Miss N. Hemington and Mr. R. White for valuable laboratory assistance, and Messrs. Clarke and Wise for assistance in handling the bull.

R. M. C. Dawson

Biochemistry Department,
Agricultural Research Council
Institute of Animal Physiology,
Babraham, Cambridge. Jan. 23.

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Glycerol Metabolism of the Brown Rot Mould *Poria vaillantii*

The characterization of the chemically unchanged lignin of woody tissues requires the removal of the cellulose with which it is associated. The successful utilization of wood-destroying organisms for the isolation of large amounts of enzymically liberated lignin[1] and for the elucidation of the mechanism of the biogenesis of lignin building stones[2–5] prompted an attempt at the isolation of a cellulolytic enzyme from the wood-destroying mould *Poria vaillantii*[6]. During studies of the cultivation of the mould, an attempt was made to use a medium containing glycerol instead of glucose as the sole carbon source, since glucose interferes in the assay of the cellulolytic enzyme which is obtained from the filtrates.

After 4–6 weeks of growth on a glycerol medium, the culture filtrates were collected and found to contain reducing substances. Analysis of the concentrated filtrate revealed the presence of acetaldehyde, dihydroxyacetone, and glucose. Acetaldehyde was identified as its dimedone derivative. The product after three recrystallizations did not depress the melting point of an authentic sample prepared in the same manner. The concentrated filtrate gave positive Seliwanoff and phosphomolybdate tests, indicating the presence of dihydroxyacetone. Glucose was identified by extraction from a paper chromatogram as its 2,4-dinitrophenylhydrazone derivative. There was no depression of melting point of a mixture of this compound and an authentic hydrazone specimen.

A cyclic mechanism, by which glucose could arise from glycerol, was first postulated by Horecker[7].

The identification of the above intermediates in the metabolic filtrates of the mould *Poria vaillantii*, grown on glycerol as sole carbon source, suggests that this cycle may be operative in the metabolism of this organism.

This study was carried out within a programme sponsored by the National Science Foundation and the U.S. Public Health Service.

Bienvenido C. Sison, jun.
Walter J. Schubert

Department of Organic Chemistry
and Enzymology,
Fordham University,
New York 58.

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Breeding of Dragonflies in Temporary Waters

Throughout Western Australia there are five or more consecutive months in which there is little or no rain. Over the greater part of the State the mean annual rainfall is less than 20 in., derived mainly from a few heavy falls. The surface-waters which result from these rains usually persist for a few months at the most; there are very few permanent, natural fresh waters. In the south-west (as at Perth), the rainfall exceeds 35 in. and is derived from more frequent lighter falls, but even here many of the surface-waters dry up from about November until April or May.

These temporary waters are colonized by many aquatic insects, and several species of both Zygoptera and Anisoptera, although not confined to such places, breed commonly in them. These include five species of *Austrolestes*, *Anax papuensis*, *Hemicordulia tau*, *Orthetrum caledonicum* and *Diplacodes haematodes*.

To breed successfully in temporary waters larvæ must either survive drying or complete their development in six months or less. Although Tillyard[1] found that larvæ of *Synthemis eustalacta* (a swamp species from south-eastern Australia) could withstand drying in sand for four months, there is no evidence that the common species of temporary ponds in Western Australia actually do so. Newly filled ponds have shown only young larvæ, and larvæ at all stages of development have been found dying in large numbers in pools from which the free water has evaporated. However, larvæ do complete development and emerge before the pools dry, and there can be little doubt that these have developed

from eggs laid in the previous April or May when the ponds first filled.

These observations have been made in the vicinity of Perth where pond temperatures vary from 40–60° F. in winter, up to 70–80° F. in early summer. Summer water temperatures are probably higher inland, and in the tropics they show a daily range of 75–112° F.

In the laboratory, rearing experiments have been carried out on three Anisoptera of temporary ponds. During these experiments, larvæ were kept in individual containers in circulating water and given an excess of food. At the upper temperature (85° F.) mortality was initially high. The results of the experiments are shown in Table 1.

Table 1. Growth of Odonata at Different Temperatures

Species	Growth period	Mean duration in days (No. of animals)		
		Outdoors 46–76° F.	70° F.	85° F.
Anax papuensis	Oviposition to hatching		14	
	4–10 mm. larva to emergence (~ 48 mm.)	176 (1)	70 (4)	45 (2)
Hemicordulia tau	Oviposition to hatching	20	10	6
	2–3 mm. larva to emergence (~ 21 mm.)	132 (6)	56 (10)	36 (2)
Diplacodes haematodes	Oviposition to hatching		10	6
	Oviposition to emergence		89 (2)	56 (3)

It is evident that, at the high temperatures found in many shallow ponds, these three Anisoptera can complete their aquatic life well within the time required to make use of temporary waters. Experiments performed by Gardner[2] with *Orthetrum stemmale capense* and *Palpopleura lucia* from Africa gave similar results, and it seems probable that other pool breeders will also show rapid growth rates. By contrast, *Acanthaeshna anacantha*, which breeds in permanent hill streams of the south-west of Western Australia, takes at least one and possibly two years to complete its development. Larvæ of this species have shown retarded growth and extremely high mortality at 85° F. and little or no acceleration of growth at 70° F.

The expenses of this investigation have been met from a University of Western Australia Research Grant. One of us (J. A. L. W.) was in receipt of a Commonwealth Scientific and Industrial Research Organization Studentship.

E. P. Hodgkin
J. A. L. Watson

University of Western Australia,
Nedlands, Western Australia.

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Occurrence of *Donsiella limnoriae* Stephensen (Copepoda, Harpacticoida) in the Southampton Area

Donsiella limnoriae was first described by Stephensen[1] in 1936 from some 20 specimens which had been found in association with *Limnoria lignorum* at Trondheim, Norway. Since then this species does not appear to have been found again, hence its occurrence in waters near Southampton is of interest. Three

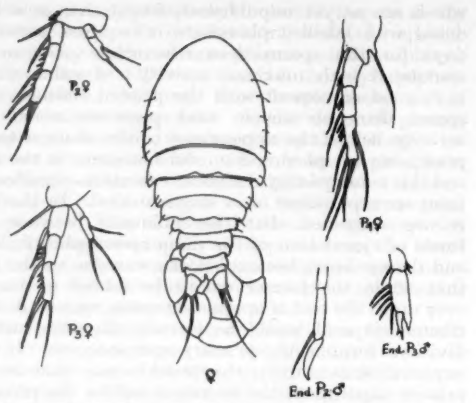

Fig. 1. *Donsiella limnoriae* Stephensen. ♀, Female with egg mass; $P_2♀$, $P_3♀$, $P_4♀$, second, third and fourth leg of female; *End.* $P_2♂$, *End.* $P_3♂$, endopodite of second and third leg of male

females were found on *Limnoria tripunctata* collected at Cowes, Isle of Wight, and three females and two males from *L. quadripunctata* at Calshot. The 'infection' was very low, at least during October when the collections were made. Only three *Donsiella* were taken from 220 *L. tripunctata* from Cowes and five from 69 *L. quadripunctata* at Calshot. While the specimens collected near Southampton could undoubtedly be identified as *Donsiella limnoriae* Stephensen, they show certain differences in structure from the description of the Norwegian specimens.

The specimens collected here are similar to those from Trondheim in general body shape and size. The structure of the endopod of the second leg, however, exhibits certain differences. It is two-jointed, the terminal joint being only a little longer than the proximal, and carrying only one inner and one apical seta; according to the original description the distal segment is more than twice the length of the proximal and carries one inner and three apical setæ[1]. In the third leg also, the second joint of the endopod is a little longer than the first in the Southampton specimens, whereas it is twice the length of the first joint in the Norwegian specimens.

In the male, the structure of the endopod of the second leg exhibits certain differences from the original description. The endopod is three-jointed, the second joint being longer than the first and carrying an inner seta; the terminal joint ends in a claw-like structure without setæ. In the Norwegian specimens, on the other hand, the terminal joint is shown as having an inner seta and to be nearly twice the length of the middle one. In the endopod of the third leg of the male, the terminal joint is small and narrow, ending in a bifid projection in the Southampton material; in the specimens from Norway, the terminal joint is broad with its outer end produced into a spinous projection and carrying two inner setæ.

When living, these copepods cling to the isopod 'host' with the help of the first leg or crawl about on the surface. They are often found in the spaces between the epimera of the body and the bases of the legs. It is likely that these copepods have been overlooked in the past because of their small size and transparent nature. Perhaps they are more widely distributed than appears from present records. A detailed description will be published when more specimens are available.

We wish to thank Prof. J. E. G. Raymont for several valuable suggestions and Mr. A. R. Hockley for some of the specimens.

S. KRISHNASWAMY
L. T. JONES

Department of Zoology,
The University,
Southampton.

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Internal Seed Disinfection with Pyridine-2-thiol-N-oxide and a Derivative

CONVENTIONAL seed disinfectants are unsatisfactory in the combat of internal parasites in seeds because they do not penetrate far enough. Successful disinfection of pea seed carrying the internal fungal parasite *Ascochyta pisi* has, however, been achieved by Dekker[1–3] using the antibiotics rimocidin and pimaricin. Using the same methods and similar material we have now found that the strongly fungicidal agents pyridine-2-thiol-N-oxide and 2-pyridyl-N-oxide-isothiourea hydrobromide are as effective as these antibiotics.

Of pea seeds (variety Eminent) which showed a high percentage of internal infection with *Ascochyta pisi* lots of 25 peas were soaked for 24 hr. in 0, 10, 25 and 100 p.p.m. of pyridine-2-thiol-N-oxide. The seeds were afterwards placed on filter paper. The number of those from which *A. pisi* developed was 17, 3, 1 and 1 respectively. Seeds of another sample were sown in soil after soaking lots of 200 peas in aqueous solutions containing 0, 10, 25, 50, 100 and 200 p.p.m. of pyridine-2-thiol-N-oxide for 24 hr. After 13 days the number of diseased plants emerging from these seeds was 20, 9, 3, 3, 2 and 1 respectively. Germination of the seeds and development of the plants was unimpaired by the pyridine-2-thiol-N-oxide treatment. The effect of this treatment on *A. pisi* is quite clear from these two experiments.

Bean seeds (*Phaseolus vulgaris*) could not be soaked because immersion in water for 24 hr. proved harmful. Thus a slurry consisting of 92 mgm. pyridine-2-thiol-N-oxide, 40 mgm. carboxymethylcellulose and 0·4 ml. water was applied to 80 seeds which were afterwards sown in soil. Emergence of the plants from treated seeds was somewhat slower than that from untreated seeds. After 12 days, however, 54 plants had developed from the treated seeds and of these 2 showed disease symptoms. The 80 control seeds gave rise to 53 plants of which 39 showed *Colletotrichum lindemuthianum* infection.

Treatment of pea seeds with 2-pyridyl-N-oxide-isothiourea hydrobromide proved as good as with pyridine-2-thiol-N-oxide. Lots of 50 seeds were soaked for 24 hr. in 0, 50, 100 and 200 p.p.m. of 2-pyridyl-N-oxide-isothiourea hydrobromide in water and afterwards placed on filter paper. The number of seeds from which *A. pisi* developed was 35, 5, 0 and 0 respectively.

These results suggest that pyridine-2-thiol-N-oxide and 2-pyridyl-N-oxide-isothiourea hydrobromide are able to penetrate into the seeds. This could be confirmed by bioassay of internal parts of treated seed. Slight systemic protection by pyridine-2-thiol-N-oxide has been earlier reported[4] for cucumber seedlings against *Cladosporium cucumerinum* and for broad bean plants against *Botrytis fabae*.

It is possible that the volatility of pyridine-2-thiol-N-oxide facilitates penetration into the seeds. 2-pyridyl-N-oxide-isothiourea hydrobromide is not volatile, however, but it is suggested to give rise to pyridine-2-thiol-N-oxide by hydrolysis under physiological conditions, for it has been found (unpublished results) to have the same fungicidal activity and mode of action *in vitro* as pyridine-2-thiol-N-oxide[5].

The insoluble copper complex of pyridine-2-thiol-N-oxide, which is its actual toxic agent[5], shows no systemic effect on *Ascochyta pisi* in pea seeds, nor does the S-carboxymethyl derivative. This latter compound is not fungicidal *in vitro*, but showed a slight systemic effect when applied to broad bean plants[4].

We are indebted to J. C. Overeem of the Institute for Organic Chemistry T.N.O. for preparing the compounds.

This work was carried out as part of the programme of the T.N.O. Research Unit for Internal Therapy of Plants.

J. DEKKER
O. M. VAN ANDEL
Laboratory of Phytopathology,
Wageningen, The Netherlands.
A. KAARS SIJPESTEIJN
Institute for Organic Chemistry T.N.O.,
Utrecht, The Netherlands.
Jan. 24.

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Choice and Application of Fungicides to Plantation Crops, with Special Reference to *Hevea brasiliensis*

IT is clear from the correspondence of this Institute during the past two to three years that the extent of care sometimes required in the choice and application of a fungicide to plantation crops is not invariably appreciated. The hazards in the latter case do not necessarily include a significant effect on the ecology of the area, but they do sometimes include a serious effect on the visual or technological quality of the plantations' finished product. This difficulty is encountered with an appreciable number of plantation crops, but it is probably particularly acute in the case of *Hevea brasiliensis* as so many valuable or potentially valuable fungicides are either (*a*) vulcanizing agents or accelerators of the vulcanization of natural rubber, for example, sulphur, which is used in the control of defoliation due to *Oidium hevea*[1], and certain salts of substituted dithiocarbamic acid which are at present under examination for the control of defoliation due to *Phytophthora palmivora*, or (*b*) extremely effective catalysts of the oxidative degradation of natural rubber, for example, copper compounds which have been examined in Ceylon[2] and elsewhere for the control of defoliation due to *Phytophthora palmivora*.

Clearly, the successful use of such fungicides in mature *Hevea brasiliensis* areas requires either the application of the dusting or spraying formulations under conditions where contamination of the product is physically impossible or the collection of data which

show that the extent of contamination of the product by the technologically active ingredient is, or can be made, of negligible significance. It has been assumed that when sprays or dusts are used for controlling leaf diseases the major sources of contamination in the field will be (*a*) drifting at the time of application, (*b*) rain-borne contamination arising through water washing down the trunks and (*c*) wind-borne contamination arising through wind, usually with rain, blowing the particles from point to point after application. On the basis of these assumptions, the first criteria mentioned above, namely, application of the fungicide under conditions where contamination is physically impossible, can probably be met either by the employment of, say, voluminous mackintosh-type rainguards which protect appropriate areas of the tree, or by the application of the fungicide at periods when the areas to be treated are out of production. It is now known[3] that rainguards which probably minimize only contamination arising through rain washing down the trunks are not invariably sufficiently effective, and detailed information on mackintosh type rainguards is not yet available.

In the absence of protective devices which preclude the possibility of contamination by the technologically active ingredients of fungicides, the actual and permissible extent of contamination must be considered in detail for each fungicide. However, with the exception of a reference by Petch[4] to a brief experiment with Bordeaux mixture, this Institute is aware of very little published information on the actual extent of contamination found under commercial conditions with fungicides employed against leaf diseases of *Hevea brasiliensis*.

In the case of fungicides based upon copper the permissible extent of contamination must at present generally be regarded as defined by the type descriptions of the Rubber Manufacturers' Association of New York Inc., which contain a clause limiting the total copper content to 8 p.p.m. The corresponding figure for manganese is 10 p.p.m.

Clearly, detailed information on the extent of contamination of processed natural rubber samples by the technologically active ingredient of one type of fungicide is only of value as an indication of the extent of contamination with other fungicides if (*a*) reasonable allowance is made for factors such as the relative proportions of the technologically active ingredients and the presence or absence of sticking and wetting agents, etc., and if (*b*) the annual differences in the climatic conditions of the particular areas involved can be largely ignored. Subject to these and certain other provisos, the information published, or to be published, elsewhere[3,5,6] on the copper content of samples of processed natural rubbers collected over the period 1955–57 from small experimental areas and from areas on commercial plantations which have been dusted with formulations containing 0–6 per cent copper at the rate of 8–16 lb. per acre per round can be tentatively generalized as follows. First, under climatic conditions similar to those found during the Ceylon low country '*Phytophthora* season', fungicides containing an ingredient which becomes of adverse technological significance when present in natural rubber at a concentration of the order of 8–10 p.p.m. should apparently only be used, against leaf diseases of mature *Hevea brasiliensis* in tapping, with very strict care at all stages in the field and in the plantation's factory even when the dusting formulation contains preferably no more than 1 per cent of the technologically active ingredient. Dusts containing 4 per cent of the technologically active ingredient can probably be employed; but the probability that certain batches of the final product may have to be rejected or be submitted to special processes in the plantation's factory appears to be increased. Secondly, in a similar manner it may be reasonable to suggest that where the care which would be taken on the plantation to minimize contamination or the effects of contamination is of an appreciably lower order, 1 or 4 per cent dusting formulations would probably be practicable, provided the relevant ingredient is not of adverse technological significance when present in natural rubber at concentrations below about 25 p.p.m. Thirdly, where the care on the plantation is of a distinctly low order the relevant concentration figure at which significant adverse technological effects are noted should probably be not less than about 220 p.p.m. A further point at present of only local practical interest is that although this Institute at present suggests[2] copper for the control of defoliation due to *Phytophthora palmivora*, it would obviously prefer to use an alternative effective fungicide which does not have a significant undesirable technological effect below a concentration of about 220 p.p.m. in natural rubber and to use this fungicide with the care required for an '8 p.p.m. fungicide' or a '25 p.p.m. fungicide'. The application of the general principle, that considerable care may be needed over the choice and utilization of fungicides for plantation crops, to the control of panel diseases of *Hevea brasiliensis* is also under examination.

I wish to thank the Administration of this Institute for permission to publish this communication.

E. J. Risdon

Rubber Research Institute of Ceylon,
Dartonfield, Agalawatta,
Ceylon.
Jan. 16.

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Selection for an Invariant Character—'Vibrissa Number'—in the House Mouse

Waddington[1] has described selection experiments in *Drosophila* in which acquired characters were 'assimilated' by the genotype. This communication describes the initial results of a mouse experiment of similar design.

The character, 'vibrissa number', was scored by addition of the number of vibrissæ in the five minor groups found on the head and forelimbs of the mouse —a total of 19 'vibrissæ'[2]. Inbred lines *Aw*101 and *CBA* showed no variation in 'vibrissa number' and it was decided to use a parent stock based on these two lines in an attempt to break down the invariant vibrissa development. If this could be done it should be possible to breed mice with more or less than 19 vibrissæ.

Since it is possible for vibrissæ to fall out or be eaten, the best evidence of a real change must, at

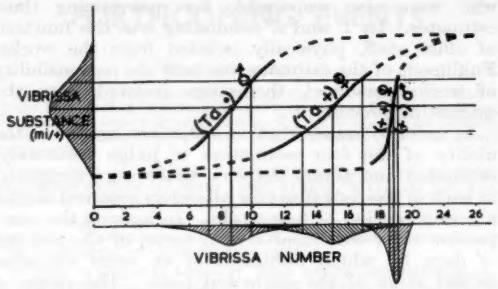

Fig. 1. Diagram illustrating the possible relationship between the genetic system determining the initiation of vibrissæ (*mi* − + genes); and the variation of vibrissa number in the (Ta − +) genotypes

least in the early stages, be looked for in the high selection line, that is, an increase of 'vibrissa number' is more convincing than a decrease. However, in an examination of 6,000 mice involving 14 strains, the post-orbital vibrissa was invariably present. Therefore, if there is loss of post-orbitals in the low line this can be taken as critical.

In order to produce phenotypic variance in 'vibrissa number', the sex-linked, semi-dominant gene Tabby (*Ta*) (Falconer, 1953) was crossed into the selection stock. Three frequency distributions are shown below the abscissa of Fig. 1. From right to left they refer to the 'vibrissa number' in (*a*) wild-type mice [(+ +) or (+ ·)], (*b*) (*T a* +) females and (*c*) (*Ta* ·) males. High and low lines were established by selecting within this uncovered variance.

Selection was applied both to (*Ta*+) females and (*Ta*·) males using consecutive matings of the form:

1. (+ +) female × (*Ta*·) male
2. (*Ta*+) female × (+ ·) male

The assumption was made that the same modifying genes influence both (*Ta*+) and (*Ta*·) scores. The changes in (*Ta*+) score support this as the two selection lines have been separated by three standard deviations in four generations.

Wild-type mice with low 'vibrissa number' became frequent in generations 5 and 6 of the low selection line and four of these mice had no post-orbital vibrissa. In generation 6, four mice with increased 'vibrissa number' appeared in the high line. Three of these mice had an extra supra-orbital vibrissa and one, 4 inter-ramal vibrissæ.

These results show, first, that there is genetic variation in vibrissa development which is not apparent in the absence of *Ta*. Using Waddington's terminology, vibrissa development is 'canalized'. Secondly, by selecting the variation which is apparent when *Ta* is present it has been possible to produce wild-type mice with both more and less than the standard number of vibrissæ. Although the genetic basis of these changes is unknown, it seems reasonable to suggest that the polygenic system controlling vibrissa development has been altered by selection.

It is possible to explain the absence of phenotypic variability in wild-type mice, despite the presence of genetic variability, by supposing a sigmoid relationship between the genetic actions and their phenotypic effects. If we assume a genetic system determining the form of this sigmoid relationship which is independent of the genetic system determining the initiation of vibrissæ, then it is possible to explain these results in terms of (*a*) the *Ta*/+ genes affecting the form of the sigmoid relationship and (*b*) a genetic system (*mi*/+) determining the initiation of vibrissæ. This is shown in Fig. 1, which demonstrates the parallel changes in 'vibrissa number' which occur when selection is applied within the Tabby genotype.

These results illustrate a function of major gene mutations in evolution, that is, to break down developmental homeostasis and so expose concealed genetic variation to natural selection.

R. B. Dun

New South Wales Department of Agriculture, Experiment Station, Trangie, Australia.

A. S. Fraser

Animal Genetics Section, Commonwealth Scientific and Industrial Research Organization, University of Sydney.

Dec. 4.

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Chromosome Variation in the *Heleocharis palustris-uniglumis* Complex

The *Heleocharis* (*Eleocharis*) *palustris-uniglumis* complex shows a considerable variation in chromosome number, the following figures being recorded in the literature: $2n = 10, 16, 32, 36, 38, 46, c.\ 69, 92$ [1]. The taxonomical implications of this variation is under discussion[2-4], but no definite conclusions have been reached. It was felt that more information about the chromosome variation was needed before definite conclusions as to the taxonomical status of the different chromosome types could be drawn.

Counts of 158 specimens, mainly collected in Denmark and Sweden, gave the chromosome numbers indicated in Table 1.

Table 1. Chromosome Numbers of 158 *Heleocharis* Plants

2*n*	16	38	39	40	42	44	46	47	48	49	51
No. of plants	2	66	21	4	8	1	42	2	9	2	1

The taxonomical investigation of this material by Prof. Th. Sørensen is now in progress. Most of the plants with $2n = 38$ correspond to *H. palustris* (L.) R. et S., whereas the 46-chromosome type corresponds to *H. uniglumis* (Link) Schult. Plants with 38–46 chromosomes and those with more than 46 are more or less intermediate between *H. palustris* and *H. uniglumis*. They are all fertile, though some of them have a reduced fertility. It should be emphasized that the plants counted do not represent random samples from natural populations because intermediate types were deliberately selected for chromosome counting. These results suggest that '*H. palustris*' and '*H. uniglumis*' represent two semi-isolated entities. Hybridization takes place in Nature, and where *H. uniglumis* and *H. palustris* grow together the populations comprise both the two pure types with 38 and 46 chromosomes respectively, F_1 hybrids with 42 chromosomes and various back-cross or F_2, F_3 . . . karyotypes. Hence the *H. palustris–uniglumis* complex represents another case of introgression in the sense of E. Anderson[5]. The 16-chromosome type which is rare in Scandinavia

but is the only type found in Greenland[4] and which is also common in southern Europe is probably completely isolated from the 38- and 46-chromosome types and should most likely be considered a separate species. It is undoubtedly split up in a number of subspecies[4]. The final decision as to the taxonomical status of the 38-chromosome '*palustris*'-type and the 46-chromosome '*uniglumis*'-type must await further morphological, cytological, and genetical investigations. The 10-chromosome type of Russian origin probably belongs to a different species. The plants of British origin with 92 and 69 chromosomes respectively which are referred to *H. uniglumis*[6] have not been found in Scandinavia. They may represent natural tetraploids and triploids respectively of this species or they may belong to a separate species. There is a conspicuous difference in chromosome morphology between *Heleocharis* and *Scirpus* species (which is one argument against merging the two genera into one). *Heleocharis* species have rather long chromosomes whereas *Scirpus* species have very tiny ones. Several *Scirpus* species have very high chromosome numbers (100 or more) and it would be interesting to know the chromosome morphology of the British 92-chromosome *H. uniglumis* type which was counted by Hartshorne (unpublished, ref. 1).

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Lise H. Sauntе

Institute of Genetics,
University of Copenhagen.

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Decision-making and the Communication of Information in an Industrial Setting

This communication is concerned with structural or organizational variables which may affect the transmission of information. It deals with a study which was made of variations in the communication patterns of four light engineering factories carrying out the same work. The communication structures in these factories were considered from the point of view of the individuals whose work required them to make decisions or estimates from production information available to them.

'Decision' in this context refers to daily operational judgments which are similar and recurrent, the effectiveness of which appears particularly dependent upon a knowledge of the outcome of previous judgments made earlier in the series. The particular decision discussed here concerns the estimate of delivery—the length of time which it is judged will be taken to complete a customer's order. Accurate delivery was especially important in the four firms studied since they were supplying components to customers who were also manufacturers with delivery dates to fulfil.

The way in which delivery time was estimated differed in the four factories. In *W* and *X* it was carried out by works estimators on the shop floor who were also responsible for maintaining their estimates. In *Y* and *Z* estimating was the function of office staff, physically isolated from the works. Fulfilment of the estimate was here the responsibility of works personnel, themselves isolated from the estimating process.

In order to assess whether variations existed in the ability of the four estimators to judge accurately, estimated and actual delivery times were compared in each of the four firms for all orders received during the same period of four weeks. In making the comparison error was measured in terms of the number of days by which fulfilment of an order exceeded or fell short of the estimated time. The range of error for each firm and a condensed distribution of items within this range are given in Table 1.

Table 1

	Estimates		Range of error	Percentage frequency of error (+ and −)				
	No.	Range		0–9 days	10–19 days	20–39 days	39+ days	
W	663	2–170	−214 to + 78	42	18	22	18	100
X	338	2–185	−197 to + 74	26	24	29	21	100
Y	540	3–205	−187 to +149	23	22	26	29	100
Z	461	3–256	−198 to +115	19	15	30	36	100

A more refined firm-by-firm comparison yielded the ranking *W*, *X*, *Y*, *Z* in order of accuracy of delivery estimating.

It is not sufficient to attribute this greater accuracy in *W* and *X* to the fact that estimators in these firms were responsible for their estimates and so 'allowed themselves longer', since their performance was superior whether the error taken into account was that of over- or under-estimation. A more reasonable explanation may be put forward in informational terms. Their position in the communication structure appeared to allow to estimators in *W* and *X* a direct, continuous and fairly immediate knowledge of the outcome of their estimates. Direct knowledge of results was available through their daily association with the manufacturing side of the business. In the case of *Y* and *Z*, any knowledge of results which existed appeared at best to be indirect, intermittent and retrospective.

This example illustrates one way in which the position of an estimator in a communication net may increase or reduce the likelihood of error in his estimates. It suggests that closer attention to structural variables and manipulation of the way in which a communication system is organized may help to reduce error commonly ascribed to unforseeable circumstances and uncontrollable factors.

The research to which this communication refers was sponsored by the Department of Scientific and Industrial Research and the Medical Research Council Joint Committee on Human Relations in Industry, and financed from Counterpart Funds derived from United States Economic Aid. A report has been submitted to the Committee. I am indebted to Mr. J. W. Whitfield under whose direction the work was carried out.

R. Sergean

Medical Research Council
Industrial Psychology Research Group,
Psychology Department,
University College,
London, W.C.1.
Feb. 4.

FORTHCOMING EVENTS

Wednesday, April 9

OLIVER BIRD TRUST AND THE SOCIETY FOR THE STUDY OF FERTILITY (in the Lecture Hall, London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1), at 5 p.m.—Dr. Gregory Pincus: "Fertility Control with Oral Medication" (Second Oliver Bird Lecture).

INSTITUTION OF ELECTRICAL ENGINEERS, RADIO AND TELECOMMUNICATION SECTION (at Savoy Place, London, W.C.2), at 5.30 p.m.—Informal Evening on "U.H.F. Test Transmissions".

INSTITUTION OF MECHANICAL ENGINEERS, STEAM GROUP (at 1 Birdcage Walk, Westminster, London, S.W.1), at 6 p.m.—Discussion on "The Combined Nuclear/Fossil Fuel Cycle".

SOCIETY OF CHEMICAL INDUSTRY, FOOD GROUP—NUTRITION PANEL (at 14 Belgrave Square, London, S.W.1), at 6.15 p.m.—Annual General Meeting, followed by the Fourth Meeting on "Some Nutritional and Allied Problems Confronting the Food Manufacturer". Dr. M. Ingram: "Technological Aspects of Chemical Preservatives"; Dr. J. M. Barnes: "Biochemical and Pharmacological Aspects of Chemical Preservatives".

Wednesday, April 9—Friday, April 11

INSTITUTE OF PHYSICS, EDUCATION GROUP (joint meeting with the SOUTH WESTERN BRANCH, at the University, Bristol)—Conference on "The Teaching of Science in Schools".

Thursday, April 10

INSTITUTION OF ELECTRICAL ENGINEERS (at Savoy Place, London, W.C.2), at 5.30 p.m.—Mr. J. A. Ratcliffe, O.B.E., F.R.S.: "Radio Observations on Artificial Satellites".

SOCIÉTÉ DES INGÉNIEURS CIVILS DE FRANCE, BRITISH SECTION (joint meeting with the INSTITUTE OF FUEL, at the Institution of Civil Engineers, Great George Street, London, S.W.1), at 5.30 p.m.—M. André Blanchard: "Lacq: Its Problems and Potentialities".

SOCIETY OF CHEMICAL INDUSTRY, MICROBIOLOGY GROUP (at Queen Elizabeth College, Campden Hill Road, London, W.8), at 6 p.m.—Annual General Meeting, followed by Dr. E. F. Gale, F.R.S.: "Nucleic Acids, What, Where, Why".

ROYAL PHOTOGRAPHIC SOCIETY (at 16 Princes Gate, London, S.W.7), at 7 p.m.—Mr. D. Causley: "Electronic Control in Photographic Printing".

Friday, April 11

BRITISH PSYCHOLOGICAL SOCIETY, INDUSTRIAL SECTION (in the Department of Psychology, Birkbeck College, Malet Street, London, W.C.1), at 1 p.m.—Mr. Robert H. Guest: "Behavioural Effects of Managerial Change".

INSTITUTION OF ELECTRICAL ENGINEERS, LONDON GRADUATE AND STUDENT SECTION (at Savoy Place, London, W.C.2), at 6.30 p.m.—Mr. R. Carruthers: "The Engineering Aspects of the British Controlled Thermonuclear Reaction Experiments".

Saturday, April 12

SOUTH-EASTERN UNION OF SCIENTIFIC SOCIETIES (at the House of the Zoological Society of London, Regent's Park, London, N.W.1), at 10 a.m.—Conference on "Conservation of Nature in South-East England".

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

LECTURER IN INORGANIC CHEMISTRY; and a LECTURER IN ORGANIC CHEMISTRY—The Registrar, Hatfield Technical College, Hatfield, Herts (April 10).

SENIOR LECTURER (with a good honours degree or higher degree in chemistry and experience in industry, teaching and/or research) IN CHEMISTRY—The Principal, Wigan and District Mining and Technical College, Wigan (April 11).

ASSISTANT LECTURER IN PHILOSOPHY—The Registrar, The University, Leicester (April 12).

LECTURER (with an honours degree in botany with subsidiary qualifications in zoology, and teaching experience) IN BOTANY—The Principal, Derby and District College of Technology, Normanton Road, Derby (April 12).

PRINCIPAL (with high academic qualifications, and good teaching and industrial experience)—The Clerk to the Governors, North Staffordshire Technical College, P.O. Box No. 23, Town Hall, Hanley, Stoke-on-Trent (April 12).

SENIOR LECTURER IN MATHEMATICS—The Secretary, Royal College of Science and Technology, Glasgow (April 14).

LECTURER IN AESTHETIC PHILOSOPHY—The Secretary of University Court, The University, Glasgow (April 15).

ASSISTANT LECTURER IN MATHEMATICAL STATISTICS—The Registrar, The University, Manchester 13 (April 18).

IMPERIAL CHEMICAL INDUSTRIES RESEARCH FELLOWS IN BIOCHEMISTRY, CHEMISTRY, ENGINEERING, PHARMACOLOGY or PHYSICS—The Secretary, The University, Aberdeen (April 18).

ASSISTANT LECTURER (with special interests or training in experimental and statistical psychology) IN PSYCHOLOGY—The Registrar, The University, Manchester 13 (April 19).

DEPUTY LIBRARIAN (with a good honours degree and experience in a university or similar academic library, and preferably professional library qualifications)—The Secretary, University College, Gower Street, London, W.C.1 (April 19).

LECTURER (with a special interest in plant biochemistry, microbiology or associate fields) IN BOTANY—The Registrar, Queen Mary College (University of London), Mile End Road, London, E.1 (April 25).

ASSISTANT IN MATHEMATICS—The Secretary of University Court, The University, Glasgow (April 26).

RESEARCH FELLOW IN MATHEMATICS—The Secretary of University Court, The University, Glasgow (April 26).

ASSISTANT LECTURER (with a special interest in some aspect of vertebrate zoology) IN ZOOLOGY—The Secretary and Registrar, University College of North Wales, Bangor, North Wales (April 30).

FOREST ENTOMOLOGIST (with a postgraduate degree in entomology, and preferably experience in forest entomology) IN THE DEPARTMENT OF ENTOMOLOGY, Waite Agricultural Research Institute (University of Adelaide)—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, April 30).

JUNIOR LECTURER IN PETROLOGY; and a JUNIOR LECTURER IN ZOOLOGY—The Registrar, Trinity College, Dublin (April 30).

LECTURER (preferably with experience in electronics and instrumentation for automatic control) IN ELECTRICAL ENGINEERING—The Registrar, Queen Mary College (University of London), Mile End Road, London, E.1 (April 30).

LECTURERS (preferably with a special interest in thermodynamics) IN MECHANICAL ENGINEERING—The Secretary of University Court, The University, Glasgow (April 30).

ENGLISH ELECTRIC RESEARCH FELLOW IN AERONAUTICS, for postgraduate research into the problems of vibration or stability and control of aircraft—The Warden, The College of Aeronautics, Cranfield, Bletchley, Bucks (May 1).

LECTURER IN CHEMISTRY—The Secretary, Durham Colleges in the University of Durham, 38 North Bailey, Durham (May 1).

READER IN MECHANICAL ENGINEERING at the Imperial College of Science and Technology—The Academic Registrar, University of London, Senate House, London, W.C.1 (May 1).

READER IN THE HISTORY OF PHILOSOPHY at the London School of Economics and Political Science—The Academic Registrar, University of London, Senate House, London, W.C.1 (May 2).

ASSISTANT KEEPER IN THE DEPARTMENT OF GEOLOGY—The Secretary, National Museum of Wales, Cardiff (May 14).

ASSISTANT LECTURER (DEMONSTRATOR) IN ANATOMY, to undertake teaching and research—The Secretary, University College, Gower Street, London, W.C.1 (May 15).

COMPUTER (preferably woman graduate) IN THE MATHEMATICS DEPARTMENT—The Assistant Secretary, University College, Gower Street, London, W.C.1.

ELECTRICAL or MECHANICAL ENGINEER IN THE DEPARTMENT OF PHYSICS, to form part of a research team developing a linear accelerator for nuclear physics research—Prof. S. Devons, The University, Oxford Road, Manchester 13.

FISHERIES RESEARCH OFFICER (with an honours degree in biology with emphasis on zoology; appropriate knowledge of chemistry and of statistical methods; and the ability to read French and possibly German) with the Federation of Nigeria, to undertake research into pond culture of local species of fish and into the chemistry and plankton populations of fish ponds to ensure the most profitable use of available nutrients, foodstuffs and fertilizers—The Director of Recruitment, Colonial Office, London, S.W.1, quoting Ref. BCD.65/14/01.

HEAD (graduate with good industrial and teaching experience) OF THE DEPARTMENT OF MECHANICAL ENGINEERING (Grade III)—The Principal, City of Bath Technical College, Lower Borough Walls, Bath.

HEAD OF THE FEEDING AND METABOLISM DEPARTMENT—The Secretary, National Institute for Research in Dairying (University of Reading), Shinfield, Reading, quoting Ref. 58/8.

LECTURER IN GEOGRAPHY, and a LECTURER IN MATHEMATICS—The Warden, Goldsmiths' College (University of London), New Cross, London, S.E.14.

LECTURER or ASSISTANT LECTURER IN INORGANIC CHEMISTRY—Prof. G. Wilkinson, Imperial College, London, S.W.7.

LECTURER (preferably with teaching experience and a special interest in biochemistry) IN PHYSIOLOGY—The Secretary, Queen Elizabeth College (University of London), Campden Hill Road, London, W.8.

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LECTURER (with some industrial research experience, and preferably teaching experience) IN PHYSICS—The Principal, Royal Technical College, Salford 5.

LECTURERS and ASSISTANT LECTURERS IN ELECTRICAL INSTRUMENTS, TELECOMMUNICATIONS, APPLIED ELECTRONICS and GENERAL ELECTRICAL ENGINEERING—The Secretary, Northampton College of Advanced Technology, St. John Street, London, E.C.1.

MASTER (well qualified) TO TEACH CHEMISTRY—The Headmaster, School House, Berkhamsted, Herts.

PHYSICIST (Scientific or Experimental Officer grade), to develop heavy particle detectors and undertake fundamental research as a member of a team studying charged particle reactions using a 50-MeV. proton linear accelerator—The Recruitment Officer (1047Y/34), Atomic Energy Research Establishment, Harwell, Didcot, Berks.

PLANT PATHOLOGISTS (with some postgraduate experience), to investigate diseases of cotton in Africa—The Secretary, Empire Cotton Growing Corporation, 12 Chantrey House, Eccleston Street, London, S.W.1.

SENIOR PATHOLOGICAL TECHNICIAN (male or female)—The Secretary, Wembley Hospital, Wembley, Middlesex.

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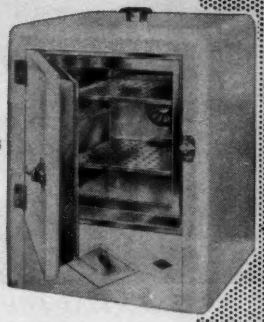

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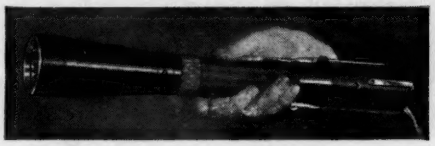

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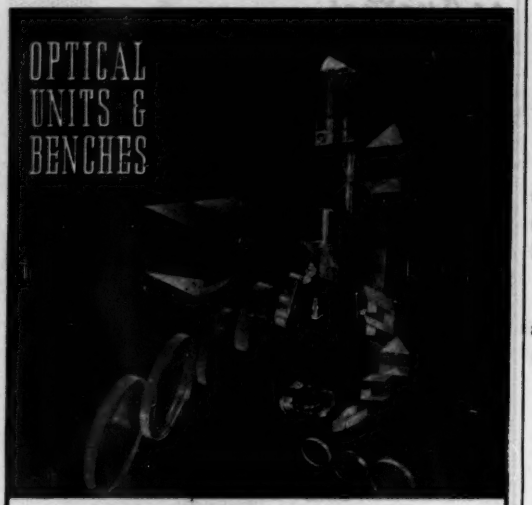

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